

The area of the site that has been exposed by erosion along the lakeshore is well under 2 ha. Even with relatively extensive areas eroded, the site would be defined as a small hamlet using criteria developed by Blanton (1972). The actual extent of the site and the total number of structures during each occupation is unknown. Although the number of excavated structurehold units decreases through time, the limited area excavated and differential preservation make any inferences regarding population changes on the site tenuous.

It appears that Tronadora and Arenal phase households utilized a single, relatively small (ca. 20 m²) structure constructed of a framework of vertical support poles, likely with a thatched roof. The households sometimes utilized interior and exterior smaller structures in addition to the main structure for special purposes, possibly including food storage or processing. Hearths were outside of the structures, and burials appeared to

have been outside of structures but within the hamlet. Direct evidence of food storage features is lacking, but the bell-shaped pits may have been used for this purpose.

Many questions remain regarding the occupations at Tronadora Vieja; however, the site offers some unique opportunities to study the prehistory of lower Central America. Future excavations should concentrate on finding areas with unmixed Fortuna Phase and early Tronadora Phase deposits to determine the date of transition from the Archaic to the Formative. Other questions concern the date of the introduction of maize to the site, and the variability of construction and structurehold units during the Formative. Tronadora Vieja has already contributed to the understanding of the Archaic/Formative transition in lower Central America, and further research can add to our understanding of this crucial period of cultural change.

5

Excavations at Sitio Bolívar: A Late Formative Village in the Arenal Basin

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INTRODUCTION

Sitio Bolívar (G-164) is situated on a small point of land on the south shore of Lake Arenal.¹ It is 1.25 km NE of the modern town of Tronadora (ARENAL 1:50,000; UTM 276300 m N X 436500 m E) at a maximum altitude of 565 m above sea level (Fig. 5-1). The site extends northward below the present surface of the lake (540 m). It is named for Quebrada Bolívar, the small drainage 350 m to the west of the site. Sitio Bolívar is currently the property of ICE; however, the site is being farmed under agreements that include the planting of trees in order to control erosion. Modern agricultural activity on the property is intensive, with the principal crops being tomatoes, beans, *yuca* (sweet manioc), and corn.

The southern end of the site is marked by a stand of *yuca* and several citrus trees. The northern half includes corn- and beanfields, which are planted to the edge of the lakeshore. A heavily overgrown bulldozed road runs east-west across the site. Current access is via a small two-track road that leaves the main road 2.5 km east of Tronadora.

The site, as defined by the extent of subsurface features on the ridge top to the south and the lakeshore margin to the east, covers an area of approximately 2.5 ha. It is situated on a landform comprising small foothills in the Arenal Valley that are dissected by a number of small drainages and that has been largely denuded for pasture.

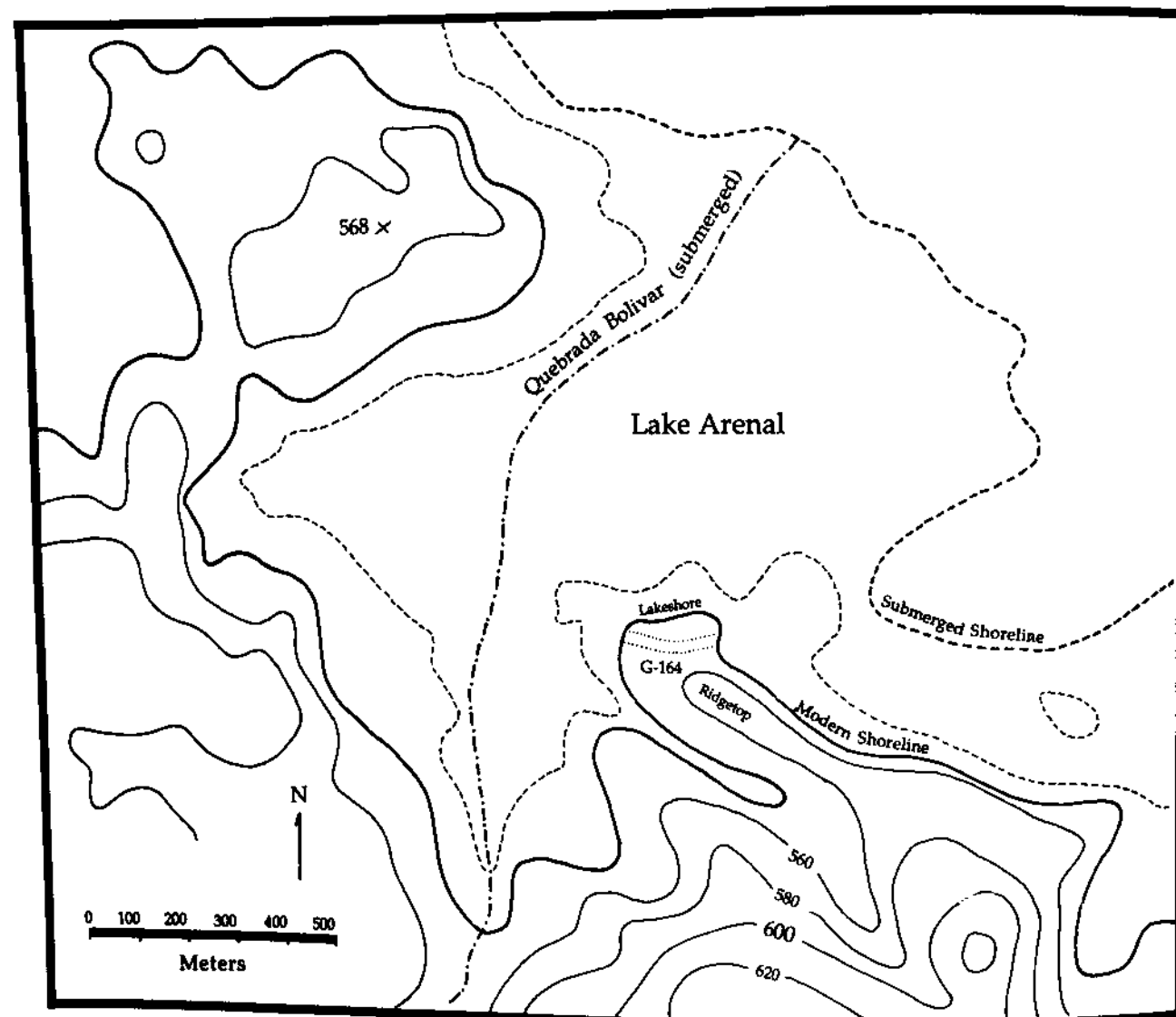


Figure 5-1. Map indicating location of Sitio Bolívar (G-164) relative to the Quebrada Bolívar and the southern shore of Lake Arenal. Map by John Hoopes.

FIELD METHODS

RECONNAISSANCE

Hoopes, Matthews, and Sheets first recorded Sitio Bolívar at the end of March 1984, during a shoreline survey of Lake Arenal (Mueller 1984a; Chap. 3). A lowering of the lake during the dry season exposed deposits 10–30 m wide along the water's edge. Artifacts were scattered along 215 m of shoreline. Surface collection produced 271 diagnostic sherds, 23 chipped stone artifacts, eight ground stone artifacts, and one small fragment of a greenstone pendant. Approximately 140 fire-cracked cooking stones were recovered. These, together with a high proportion of monochrome ceramics, suggest the remains of domestic activities.

At the time of the initial reconnaissance, a local informant (Abel Gutiérrez) showed me a large number of round boulders in and around a looter's

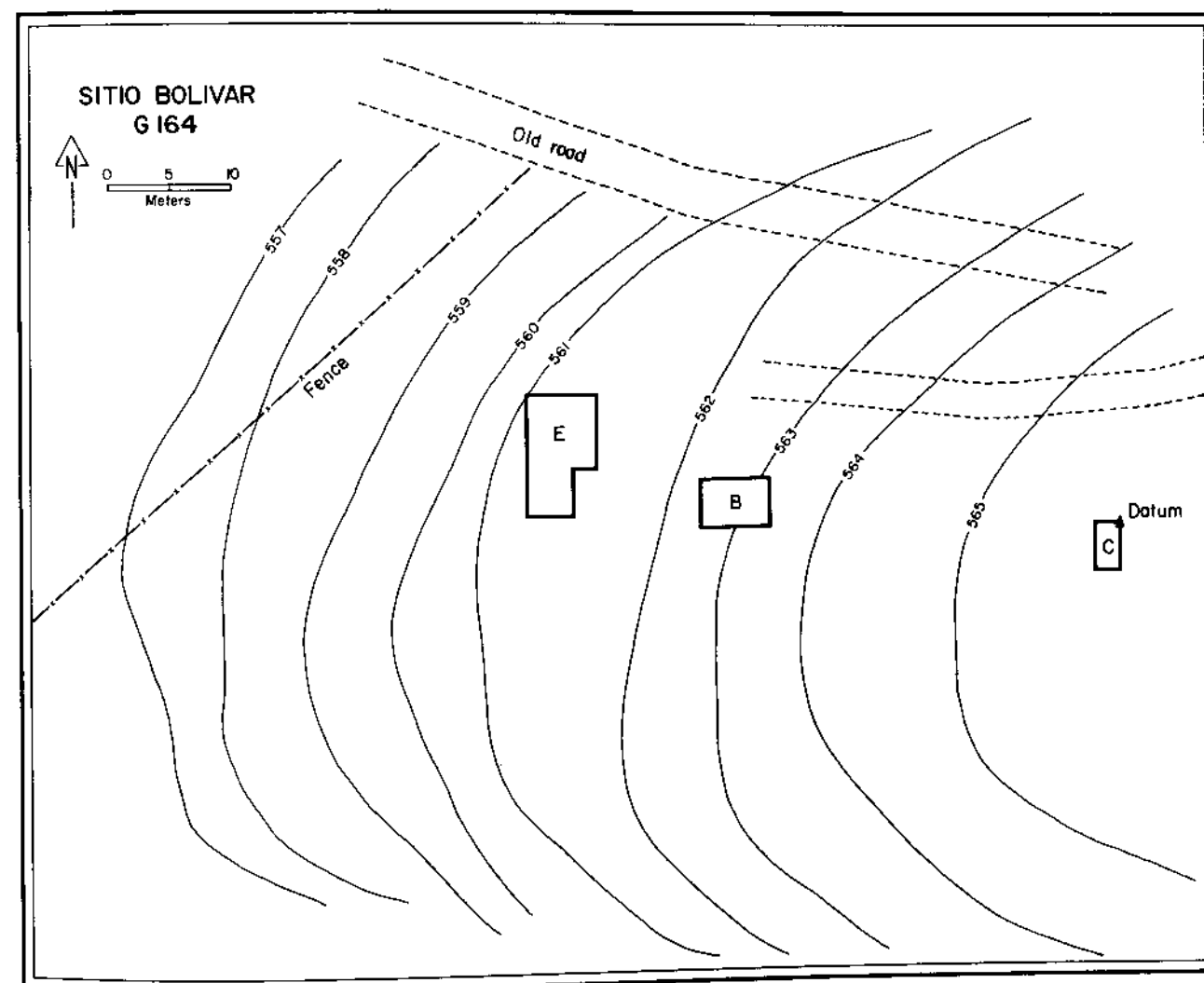


Figure 5-2. Site map of the ridge top portion of Sitio Bolívar, indicating the relative locations of Operations B, C, and E. Map by John Hoopes.

pit near the top of the ridge overlooking the lakeshore. Their size and location suggested prehistoric burial features. The informant also mentioned that waves along the lake's edge had exposed whole vessels, subsequently removed by local collectors. Mueller, assessing the volcanic stratigraphy in the cut banks of the eroded lakeshore, noted a high density of artifacts embedded in layers below Unit 50.

SURVEY AND EXCAVATION

The specific goals of subsurface testing at the site were (1) to determine the nature of the disturbed stone features on the upper part of the site, and (2) to determine whether there was a functional difference between the features on the shoreline and those on top of the small knoll. Our working hypothesis was that the shoreline, with its high percentage of monochrome ceramics and large

quantity of thermally fractured debitage, was a domestic activity area while the hilltop, with large stone features and evidence of looting, was mainly the locus of funerary activities.

We used a manually operated posthole digger to identify buried features and to determine the extent of artifact distribution, digging small holes every 10 m along two 70 m transects. Cultural materials appeared in nearly every posthole, indicating a continuous distribution of artifacts to the north and west of the site datum. Although some material was as shallow as 30 cm, we located the majority of artifacts between 90 and 110 cm below the present ground surface (Fig. 5-2).

LAKESHORE INVESTIGATIONS

Sheets and Mueller directed investigations along the modern lakeshore at the northern end of the site. They included excavation of a 2 m × 4 m test unit (Operation D; Fig. 5-3) and the cleaning and mapping of several features exposed by wave action.

OPERATION D

Operation D was placed next to in situ deposits in an eroded section of the lakeshore that had a particularly high density of surface artifacts. Given the domestic character of the lakeshore assemblage, we hoped that this operation would reveal intact domestic features and provide a stratigraphic cut with which we could determine the associations of cultural materials and tephra units.

Ceramic and lithic artifacts were present in Operation D, but we encountered no intact cultural features; however, the excavation did provide a continuous stratigraphic section from present ground surface to the sterile Aguacate Formation (Unit 65). The strata in this operation confirm the preservation of the regional tephra stratigraphy at this site. They are presented in Table 5-1.

In the southeastern corner of the operation, a light, fine, tephra-laden stratum approximately 15 cm thick was present as a small lens directly on top of Aguacate. It is probably Unit 61. The greatest artifact density was in the strata beneath Units 40/41, that is, in Units 50, 54, and 55. The greatest concentration of materials appeared in Unit 54—a light-colored stratum 10–15 cm thick.

The ceramic assemblage included types Charco

TABLE 5-1
STRATIGRAPHIC UNITS IN OPERATION D

Depth	Characteristics
0–30 cm	Mixed, containing Units 10 and 20, corresponding to the modern cultivation zone
30–50 cm	Unit 30; dark gray, sandy, and friable
50–60 cm	Units 40/41. Yellow/gray sandy stratum
60–70 cm	Unit 50, dark gray to black soil
70–90 cm	Lighter horizon, Units 52/53
90–105 cm	Dark, clay-laden, with small white and yellowish particles. Unit 54, possibly mixed with eroded Unit 55
105–115 cm	Black, clay-laden. Probably Unit 60 and compressed lower strata, overlying the Aguacate Formation

Black-on-Red, Mojica Impressed (Corrida and Arrastrada varieties), Guinea Incised, Los Hermanos Beige and Los Hermanos Beige: Cervantes Variety—all of which date to the latter portion of the Late Arenal Phase (cal AD 300–600; Chap. 10). We found no ceramics from earlier or later phases and there was little apparent temporal variation within individual ceramic types.

LAKESHORE FEATURES

As noted earlier, the rise and fall of the lake between wet and dry seasons dissects Sitio Bolívar laterally at the water's edge. When the water level is low, the shoreline exposes a section of cultural deposits as much as 30 m wide. Although the erosion of softer strata is severe, harder strata such as the Aguacate Formation and portions of overlying tephra layers survive. In these we found several well-preserved archaeological features.

The lakeshore features consist of the following (in the order of their discovery):²

A6/1: A short, outflaring-necked, globular Los Hermanos Beige: Espinoza Variety olla (cooking pot). Its base was in Unit 65, but this vessel probably was deposited at the same time as Unit 54.

A6/2: A Los Hermanos Beige jar in a black stratum (Unit 60?) overlying Unit 65. Carbonized material on its interior indicates that it was used for cooking.

A8: A prehistoric firepit, demarcated by a circular depression 135 cm in diameter outlined by red, oxidized clay (Fig. 5-4). It contained 65 fragments of fire-cracked rock, 10 complete cooking stones, charcoal (C-14 sample Tx-5272), 14 sherds (one with charcoal on the interior), and lithic debris.

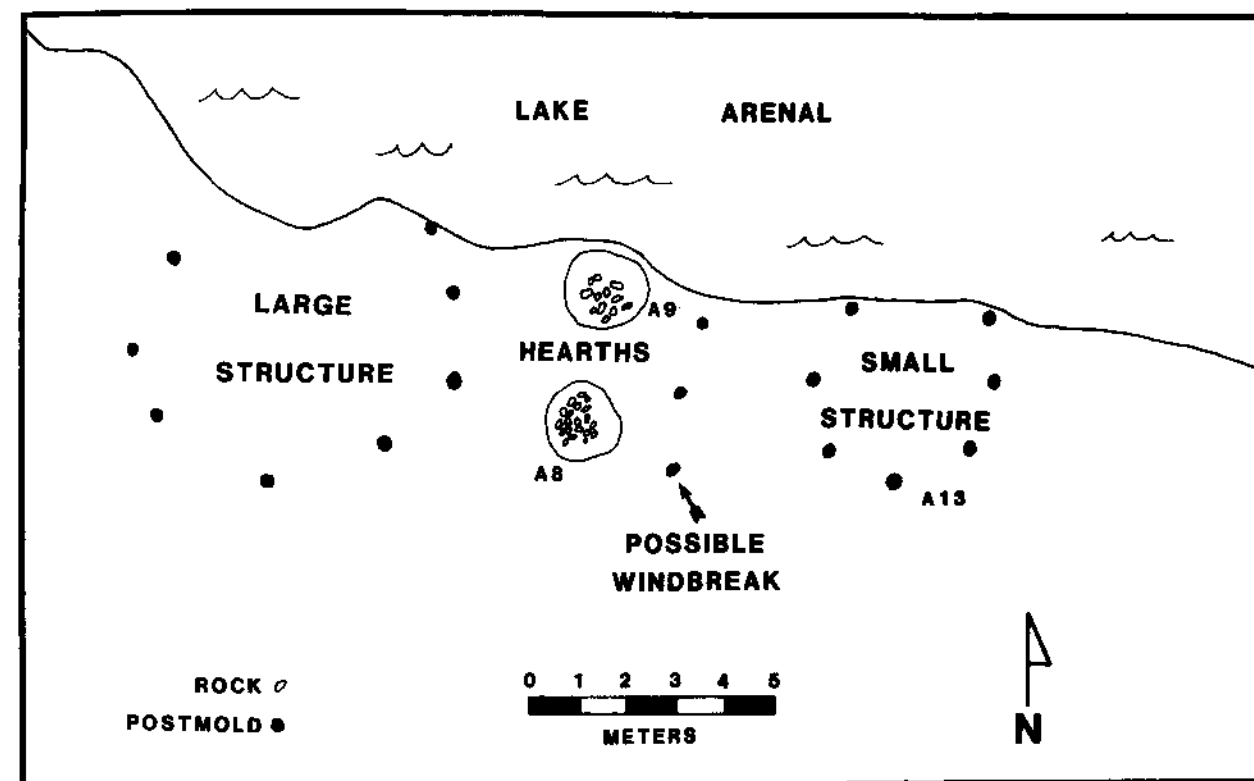


Figure 5-3. Sketch map of the lakeshore portion of Sitio Bolívar, indicating features exposed by wave action. The map indicates the relative locations of two circular structures, with two large firepits between them. Three postholes near the hearths may represent traces of a windbreak. Map by Brian McKee.

Figure 5-4.

A firepit located between the circular domestic structures in Figure 5-3. Fire-cracked cooking stones are visible in a matrix of charcoal and burned clay at the base of the feature. A posthole of what may have been a windbreak is visible as a dark circle in the upper right corner. Photograph by Payson Sheets.



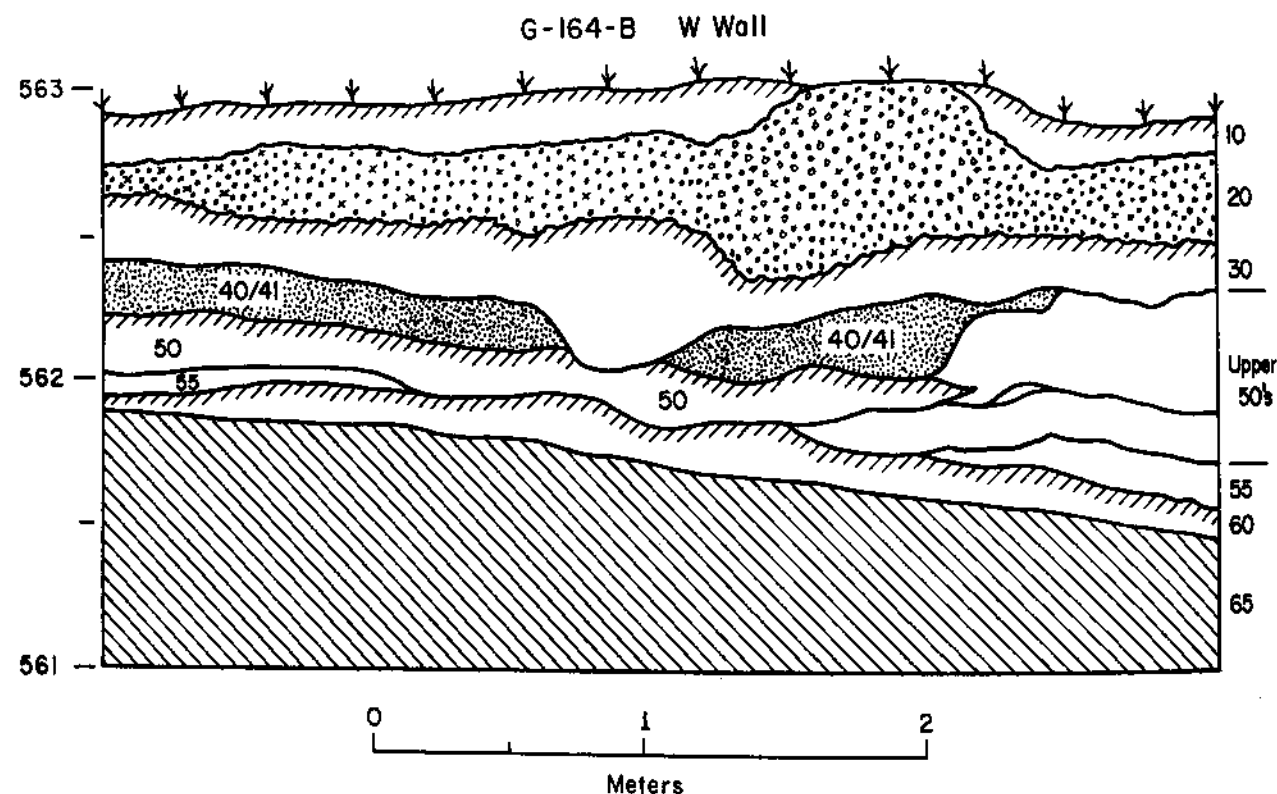


Figure 5-5.
Stratigraphic profile of the west wall of Operation B. Most of the mortuary activity was associated with strata below Unit 50. Drawing by John Hoopes.



Figure 5-6.
A midden feature in Operation B (G-164-B6). This feature probably represents the redeposition of broken vessels and other debris from previously utilized portions of the ridge top cemetery. Photograph by Payson Sheets.

A9: A second firepit, one meter NE of the first (Feature A8). Oval in shape, it measures 145 cm × 170 cm and contained 149 fragments of fire-cracked rock, large quantities of charcoal (C-14 sample Tx-5269), 29 sherds (including one jar neck fragment), and lithic debris (including one metate fragment). We found the artifacts on top of fine, hard black surface within the burned and oxidized margins of the feature. Differences in the amount of fire-cracked rock between A8 and A9 suggest that the latter had been cleaned after use.

A10: A probable firepit on the shoreline between Features A7 and A8. It measures approximately 45 cm in diameter and contained 17 fragments of fire-cracked rock, 4 small body sherds, and a small amount of flaked lithic debris. It was filled with a sandy, dark-gray tephra.

A11: A small firepit containing 7 fire-cracked rock fragments and 75 sherds, including rims from nine Los Hermanos Beige bowls, two Los Hermanos jars, a small carinated, complex-silhouette bowl of unidentified type, and a fragment of a gadrooned jar of Los Hermanos Beige: Espinoza Variety.

A12: Another probable firepit containing 1 complete cooking stone, 3 fragments of fire-cracked rock, and 19 sherds (including rims of a Los Hermanos Beige bowl and jar).

A13: The remains of a small structure, as indicated by a circular pattern of six postholes, spaced 120 cm to 135 cm apart. The feature had been partly eroded by wave action, leaving approximately 60% of the floor intact. Postholes vary from 36 cm to 45 cm in depth and 13 cm to 15 cm in diameter. One has a small "pocket" appended to one side, perhaps traces of an extra post. The enclosed area is about 3 m in diameter, for a total internal area of 7 m². Nothing remains of the living surface inside or outside of the feature, with the exception of a small, elevated patch of hard earth at the western end.

We identified a second round structure immediately to the west of A13. (We did not assign a lot number because we collected no material from it.) This feature is larger than the first and marked by eight postholes spaced from 1.30 m to 2.30 m apart. With the exception of the largest span, at the SW end of the feature, the average distance between them is about 1.5 m. The entrance was probably located on the southwestern side, which faces away from the prevailing winds. The postholes range from 14 cm to 19 cm in diameter. Although erosion had claimed the northern end of the feature, it is estimated that 60% to 70% of the

total area is preserved. The structure has a reconstructed diameter of 5.5 m, for a total area of about 24 m². Unfortunately, all traces of the floor had eroded away.

A14: A small, roughly rectangular pit measuring about 140 cm × 110 cm, filled with a mixture of sand and Aguacate Formation clay. It contained 2 fragments of cooking stones and 188 sherds, including fragments of Mojica Impressed jars and both bowls and jars of Los Hermanos Beige.

We found several other features interpreted as postholes in the vicinity of the hearths and the circular structures; however, none demonstrate structural plans as clear as the aforementioned circular structures except for a small group of holes to the SW of the larger circle. This group was interpreted as the remains of a small wind-break built to shelter the two firepits (A8 and A9) from prevailing northeasterly winds.

INCIDENTAL LAKESHORE FINDS

We found a fluted Clovis-style point made of local chalcedony (Melson, personal communication to Sheets, 1985) under water 50 cm to 100 cm deep a short distance off the beach. This artifact greatly predates the major occupation of Sitio Bolívar (Chap. 11). We also found a fragment of a small greenstone pendant offshore (Chap. 12).

RIDGE TOP INVESTIGATIONS

OPERATION B

Operation B was located on the ridge top immediately to the south of the disturbed area of large stones noted on our initial survey of the site. The purpose of this operation was to discover whether any of the looted features remained intact and to expose a large enough horizontal area to judge their shape and size. At its maximum extent, Operation B provided a total exposure of 24 m².

Surface clearing revealed that large, rounded boulders visible on the surface had been moved by looters. Informants stated that the site had been looted within two years of our arrival; however, the presence of intact Unit 10 tephra above looted deposits clearly indicates that some looting had occurred prior to the 1968 eruption of the Arenal Volcano (Fig. 5-5). The informants also reported that no one had found anything at the location but large stones.

The upper 20 cm in Operation B were badly disturbed by agricultural activity and this "plow

zone" was excavated quickly. Below this, excavation proceeded in 10 cm levels to a depth of 80 cm. Screens were not used; however, an attempt was made to collect all ceramic and lithic artifacts.

Stratigraphy

Modern disturbance, possibly as a result of deep-rooted *yucales* (manioc gardens), was evident to a depth of 50 cm throughout Operation B. Looting was heaviest in the eastern portion of the operation, where it reached depths of as much as 1 m. Unit 20 was present only in small patches throughout the operation. In the western half of the operation, patches of a harder matrix—possibly Units 40/41—were present at about 50 cm below the present ground surface. All strata above Unit 50, located approximately 60 cm to 80 cm below the surface, had been disturbed. Unit 50 itself was also somewhat disturbed, as indicated by the presence of Arenal Phase sherds in overlying levels—a context that is inconsistent with their stratigraphic position at other sites (Chap. 10).

Unit 50 overlies a large feature of ceramics, lithics, and other cultural debris (Fig. 5-6) associated with Unit 54—a light brown/orange stratum characterized by the presence of a large number of small white particles. This in turn overlies a hard, black matrix with a maximum thickness of 5 cm and traces Unit 55, a light yellow/orange, sandy tephra layer, which had probably been disturbed by cultural activity. When dry, the black matrix could only be removed with *macanas* (heavy hoes) and picks. Sherds embedded in it were identical to those of the feature above and probably do not represent an earlier occupation. This hard, black layer is situated directly on top of the Aguacate Formation substrate. It represents the partial erosion and compression of Unit 60 and underlying strata.

Features

Although several loose boulders that had been moved by looters were present on the surface, the broad, thick deposit of ceramics, chipped stone, and ground stone debris at 80 cm to 125 cm below the modern surface was the principal cultural feature in Operation B. This feature averaged 30 cm to 40 cm in thickness and covered an area of at least 16 m². It appeared to have been deposited within a short period of time and was excavated as a single lot (G-164-B6).³ It was found to contain

9,856 sherds and 1,229 lithic artifacts, as well as a number of important botanical samples.

Initially, the feature appeared to consist of a relatively small number of vessels smashed at the same time. The large stones removed by looters suggest a large mortuary feature, and we assumed that the deposit of broken vessels represented a pile of ritually smashed offerings similar to features overlying Curridabat Phase burials at sites such as La Pesa Vieja (Snarskis, personal communication, 1984). Subsequent analysis, however, indicated that the assemblage was domestic in nature and consisted of hundreds of different vessels, few of which were complete.

The midden of sherds and lithic debris covered two small features. We have interpreted the first (G-164-B17) as either a hearth or a small burial pit, located at a depth of 110 cm below the present ground surface. It measures approximately 60 cm × 80 cm and was excavated into the Aguacate Formation to a depth of 20 cm. On the west it is enclosed by six large stones, one of which had fallen into the depression. In the southwestern corner is a small (6 cm rim diameter) Los Hermanos Beige outflaring-rim jar. Charcoal from the feature yielded a C-14 date of 770 (399) 200 cal BC (Tx-5271: 390 BC ± 170).

The second feature (G-164-B8) is a small pit excavated into the Aguacate Formation from a mixed, brown matrix. It is oriented roughly NE-SW and measures 115 cm × 65 cm with a maximum depth of 28 cm. The pit expands slightly below the surface from which it was excavated, undercutting the Aguacate matrix along its eastern edge. The only artifacts in it were the remains of a large, outflaring-rim Los Hermanos Beige jar, part of a large Mojica Impressed jar, and two large sherd disks (8 cm and 9 cm in diameter and 0.5 cm thick) from a single vessel of the same paste and thickness as the Hermanos jar. While it did not contain any trace of bone, its depth and shape, its location beneath a thick layer of broken pottery, its excavation into the Aguacate Formation substrate, and the associated artifacts suggest that it was a burial pit. The small size of the pit suggests that it was either a primary child burial or a secondary adult burial.

Artifacts

The painstaking matching of rim sherds of identical type, diameter, and thickness to estimate the minimum number of vessels represented by the assemblage indicates that at least 1,000 different

vessels are represented by 1,492 diagnostic sherds from G-164-B6 alone. Over half of these are Los Hermanos Beige. The most common vessel forms are jars with outflaring, unthickened rims (205 vessels), outcurving-necked jars with exteriorly thickened rims (184 vessels), and open bowls with exteriorly thickened rims (122 vessels). Other important types are Mojica Impressed (99 vessels), Charco Black-on-Red (more than 50 vessels), Cervantes Incised-Punctate (27 vessels), and Guinea Incised (17 vessels). All of these are important types of the latter half of the Late Arenal Phase and suggest a date for the assemblage between cal AD 300–600. This time range, narrower than that for the Late Arenal Phase as a whole, is based on (1) a radiocarbon date from the feature of cal AD 261 (398) 435 (Tx-5273: AD 290 ± 70); (2) the close similarity between the ceramics from this assemblage and those of the Linear Decorated Period (AD 300–500) as proposed by Baudez (1967: 207); (3) the presence of a small amount of Carrillo Polychrome, usually dated to the Early Polychrome Period (AD 500–800; see Chap. 10); and (4) the absence of any typical Silencio Phase types in the assemblage. The radiocarbon date was obtained from a consolidated sample of charcoal recovered from the matrix of the thick midden feature 125 cm below the present ground surface.

The assemblage suggests redeposited refuse rather than pottery broken in place. Sherd size is predominantly small to medium (less than 7.5 cm maximum dimension) and there were no fully reconstructable vessels. The nature of this midden is puzzling. The only complete ceramic artifact we found in Operation B is a crude, unslipped, miniature tripod bowl, only 2.2 cm high with a rim diameter of 3 cm. It was probably a child's toy. Not far from this was a perforated sherd disk spindle whorl, 7 cm in diameter. Both of these objects indicate domestic activities; however, sherds with carbonized residue—common in domestic deposits—were absent.

Ground stone artifacts (Chap. 12) support the interpretation of the feature as a household midden. Virtually all of the ground stone artifacts, including manos and metates, are broken or unfinished, and all fragments are small (maximum dimension less than 20 cm). The feature contained six metate fragments, five mano fragments, two small burnishing stones (used in the manufacture of ceramics), and one small, unidentified ground stone fragment. Also present was a small, tabular, unfinished ground stone pendant with two incomplete, biconical perforations.

Chipped stone examples include 56 percussion debitage flakes, 5 flake cores, and 1 percussion blade (Chap. 11). Cooking stones, of which we found 943 fragments and 17 whole examples, are the most abundant lithic category. In addition to these were 6 small, rounded pebbles and a total of 115 unclassified pieces. Chipped stone was mostly fine-grained dacite (49 pieces), with only 7 fragments of chalcedony and a few rare pieces of other materials. Only 2 hinge fractures were found in a total of 56 flakes—an indication of highly skilled knapping (Chap. 11). Sheets interprets this assemblage as clearly domestic in nature. He has suggested classification of this deposit as a "secondary midden," that is, a collection of waste material that was redeposited in a location different from that of its original disposal.

Botanical Remains

We recovered a small amount of carbonized, macrobotanical material from deposits in Operation B. Aida Blanco of the National Museum of Costa Rica identified these as two fragments of gourds (*cucurbitaceae*), two seeds of *nance* (*Byrsonima crassifolia*), four palm seeds (*Scheelia*, *Acrocomia*, or *Elais* sp.), and three kernels of maize (*Zea mays*). We identified an additional palm seed in a thin stratum between the large sherd feature and the surface of Aguacate (Chap. 16).

The presence of maize in this assemblage indicates its cultivation during the Late Arenal Phase; however, the presence of tree crops also indicates the concurrent gathering of wild foods. A combination of wild plant gathering and garden cultivation was probably characteristic of most indigenous Costa Rican subsistence economies.

Discussion

Ceramic analysis indicates that the pottery from the midden feature in Operation B represents waste material and broken vessels rather than ritual offerings broken in place. As with Operation E (see below), the presence of unfinished artifacts and small pieces of manos and metates, as well as a small amount of carbonized seeds, indicates that the midden's origin was ultimately domestic.

The presence of domestic debris, however, does not necessarily indicate the presence of dwellings. The ridge top portion of the site appears to have served as both a cemetery and a dumping ground

TABLE 5-2
STRATIGRAPHIC UNITS IN OPERATION C

A gray stratum with particles of Unit 20 lapilli
A brown stratum, possibly Unit 30
A black, uncompacted stratum, Unit 50
A brown compacted stratum, probably Unit 54
A brown stratum, Unit 64, mixed with Unit 61 tephra
The base stratum or Aguacate (Unit 65)

for broken pots and household artifacts. The midden feature probably represents a secondary deposition of this material—or perhaps midden material associated with burials (see below)—as a result of excavations for new tombs in a previously utilized section of the cemetery. This would explain the small sherd size and the large number of fragments from different vessels. Ceramic types present suggest that the contents of the feature accumulated over the space of two hundred or three hundred years. The lack of internal stratigraphy and soil development, however, suggests that the midden itself represents a short-term depositional event.

OPERATION C

Operation C was a 2 m × 2 m excavation unit with its northeast corner at the site datum. We placed it near the highest point of the site to explore the stratigraphy of the ridge top portion of the site and to identify funerary or domestic activities.

The stratigraphy for the operation consists of six strata, listed in Table 5-2. The upper 30 cm had been heavily disturbed by modern farming activities, and gray lapilli from Unit 20, which was not intact, were scattered throughout this level. Unit 50 and Upper 50s strata extend beneath the disturbed level to a depth of approximately 80 cm below the present ground surface.

The heaviest concentration of materials was in Unit 54, a stratum approximately 20 cm thick that contained both ceramics and lithics. We found a metate support and a mano fragment together at a depth of approximately 75 cm. In lower levels, we found five stones (each 10 cm to 15 cm in diameter) on the surface of Unit 61. We found a shallow, basin-shaped pit, 82 cm at its widest point and 11 cm deep, excavated into the Aguacate Formation in the northwest corner of the operation. We discovered broken pottery and chunks of Unit 61 tephra in the fill of the pit, but the feature's stratigraphic origin is unknown.

Artifacts

Lithic remains suggest that the assemblage from Operation C is primarily domestic in nature. The three pieces of ground stone include a bar mano fragment, a conical metate leg, and a grinding stone similar in morphology to artifacts from other parts of the site (Chap. 12). We also recovered a total of seventy-three pieces of thermally fractured rock and two complete cooking stones. We found all but four pieces of flaked stone debitage in the lower 30 cm, with the greatest concentration coming from directly above and within Unit 61 (Chap. 11). These levels also yielded a flake core, a hammerstone, and two small water-worn pebbles like those found in direct association with the remains of an early dwelling at Tronadora Vieja (Chap. 4). Other lithic artifacts include seven pieces of general percussion debitage and twenty-five unclassifiable items.

Botanical Remains

Botanical remains from Operation C consist of three fragments of either *Crescentia* or *Lagenaria* from Unit 54. We also recovered two samples of carbonized wood.

Discussion

This operation was useful for revealing the stratigraphic sequence in a relatively undisturbed portion of the ridge top. Its artifactual assemblage is suggestive of domestic activities such as food preparation and artifact manufacture; however, the artifacts are all fragmentary and were not found in association with any recognizable habitation features. They probably represent redeposited household debris from another portion of the site (as do the materials in Operation B).

OPERATION E

Operation E was begun as a 2 m × 2 m excavation unit with its southeastern corner located 45 m west and 10 m north of the site datum. It was later expanded to a total of 22 m². The purpose of the excavation was to investigate a concentration of large stones discovered during posthole testing.

Stratigraphy

Unlike the features in Operation B, those in Operation E had not been disturbed by looting. Natu-

ral strata that overlay the cultural features, above and including Unit 50, were intact (Fig. 5-7). In the first 2 m × 2 m square excavated in Operation E, we recognized Units 10, 20, 30, 40/41, 50, as well as a mixed, clay-laden brown stratum with yellow/orange flecks—probably Unit 54. This overlies Unit 64, which in turn overlies the Aguacate Formation (Unit 65).

The concentration of stones proved to be part of a large mortuary feature that consisted of burial pits outlined and covered by large boulders. These were in turn covered with a layer of ceramic and lithic artifacts (Fig. 5-8). This feature is located in the strata below Unit 50, in some places overlain by what appear to be Units 52 and 53 and in others overlain directly by Unit 50. In general, the strata below Units 52 and 53 are very mixed; however, portions of Unit 60 and Unit 61 are intact directly beneath the stone alignments. Upon excavation, it was evident that the stones had been placed around the perimeters of several burial pits excavated into underlying strata sometime during the formation of Unit 54.

Features

The principal cultural feature in Operation E consists of a layer of over two hundred large (30–50 cm maximum dimension), rounded boulders and cobbles overlain by a dense deposit of sherds, lithic debitage, and ground stone fragments. This deposit of tightly packed boulders probably appeared as a low stone mound, less than 1 m high and at least 8 m to 10 m in diameter, prior to its burial by later tephra deposits and the associated soil development. Although we were able to define the eastern, southern, and western edges of the feature through excavation, we could not determine whether the original plan was round, square, or amorphous. The northern edge of the feature continues beyond the limits of the excavation.

Most of the large stones that form this feature were not deposited with care. Many of the boulders fractured in place, probably from violent impacts as they were tossed on top of one another. Large, unmodified percussion flakes found throughout the layer of stones were produced as they were thrown together.

Stone Enclosures

Despite the haphazard appearance of most of the stones capping the feature, some of the large

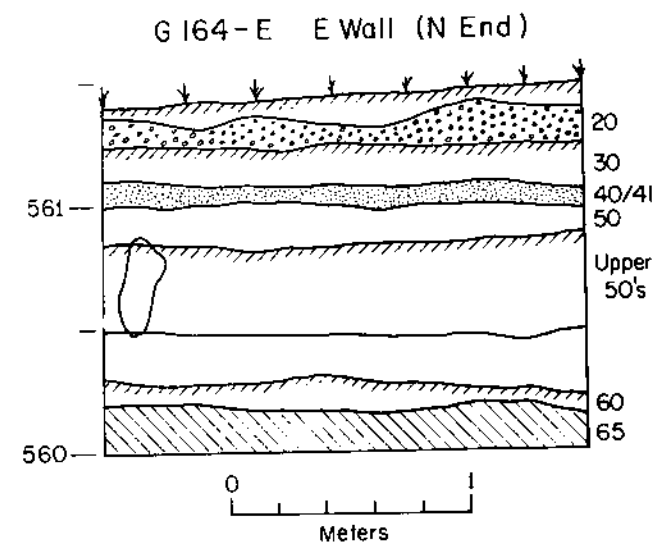


Figure 5-7. Stratigraphic profile of the north end of the east wall of Operation E. Tephra layers represented by Units 40 and 41 are visible as light bands. Mortuary activity at the site ended prior to their deposition and was associated with strata below Unit 50. Drawing by John Hoopes.

Figure 5-8. Dense artifact scatter above the layer of large rocks and boulders in Operation E. This feature represented the smashing of a large quantity of ceramic vessels and stone tools. Photograph by Payson Sheets.



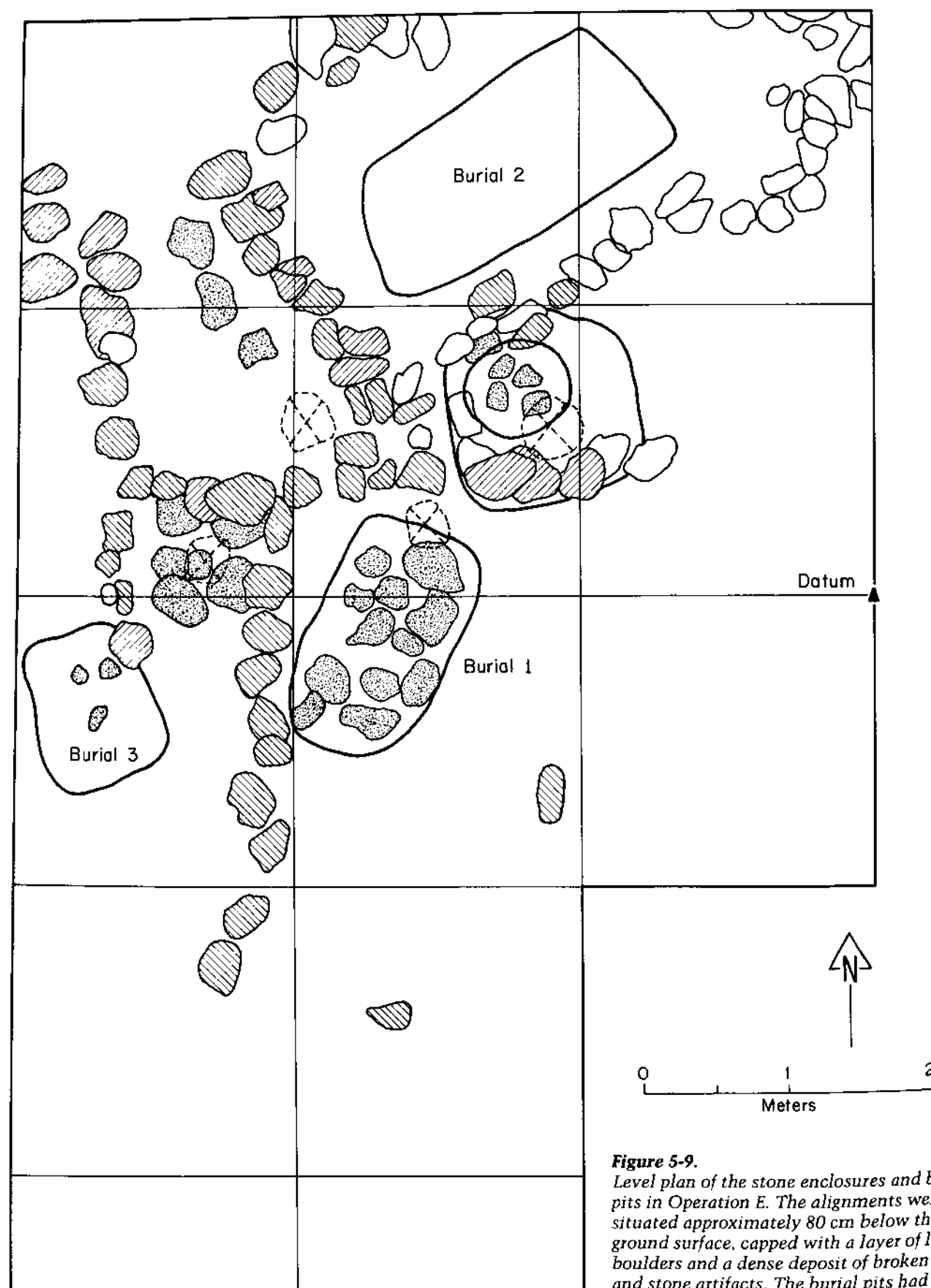


Figure 5-9. Level plan of the stone enclosures and burial pits in Operation E. The alignments were situated approximately 80 cm below the present ground surface, capped with a layer of large boulders and a dense deposit of broken pottery and stone artifacts. The burial pits had been excavated into the sterile Aguacate Formation substrate. Map by John Hoopes.

stones in the deposit were found to be standing upright in linear arrangements (Fig. 5-9). In order to define these arrangements, all of the stones that were not upright or part of the alignments were removed after they had been mapped and photographed. This left four roughly rectangular stone enclosures.

We excavated the interior of each stone enclosure down to the sterile Aguacate Formation substrate. This revealed three roughly oval depressions that we have interpreted as burials on the basis of their similarity to features found elsewhere in the Cordillera (see below). In addition to there are two features whose functions are uncertain. One is a concentration of middle-sized (ca. 20–30 cm) stones in a roughly rectangular pattern at about 20–30 cm below the upper layer of the large stone feature in the southeastern enclosure. The other is a deep, circular pit, approximately 1.10 m deep and 74 cm in diameter, that contained several small sherds and three small (10–15 cm in diameter) stones. The latter is both deeper and narrower than the features interpreted as burials, but may nonetheless represent a vertical burial pit.

Burial 1

Burial 1, a rectangular pit 1.68 m long, 92 cm wide, and excavated to a depth of 15 cm to 25 cm into the Aguacate Formation, is situated directly beneath one stone enclosure. The only cultural materials we found in this feature are several sherds, one piece of heat-cracked rock, and a small bifacial flake. No skeletal material was present, and tests for the presence of bone collagen in soil samples were negative.

Burial 2

Burial 2 is another rectangular pit, 2.26 m long, 1.06 m wide, and excavated 32 cm into the Aguacate Formation. As with Burial 1, the sides of the pit correspond to the stone alignments above it, indicating that the alignments defined the boundaries of individual tombs. We found no evidence of bone or bone collagen in the feature, nor were there vessels or other grave goods.

Burial 3

Burial 3 is located near the western edge of the stone feature, roughly parallel to the alignment of stones that delineate the western edge of Burial 1.

It is marked by a smaller (1.06 m long and 90 cm wide) and much shallower (2–3 cm into the Aguacate Formation) depression than the other features; however, it contained a single rounded-bit celt. We found two straight-bit celts near this pit at the base of the stone alignment delineating Burials 1 and 3. As with the other burials, we found no traces of bone in this feature.

Artifacts

Ceramics

We collected all of the sherds encountered during the excavation of Operation E; however, given the very large number of plain body sherds, we analyzed only the total of over three thousand sherds diagnostic as to vessel form or decoration. The vast majority of these appear to have come from whole vessels that were broken on the stones or otherwise deposited at the feature. Although we matched rim sherds and decorated pieces to the maximum extent possible in order to determine the minimum number of whole vessels represented by the assemblage, we reconstructed no whole vessels from the feature. The most common types present were Los Hermanos Beige, Charco Black-on-Red, Mojica Impressed: Corrida and Arrastrada varieties, Guinea Incised, an unnamed red monochrome, and Los Hermanos Beige: Cervantes Variety (Chap. 10). These help place the cultural features at the end of the Late Arenal Phase (cal AD 300–600). There were some differences in the frequencies of specific types between the assemblages in Operations B and E. For example, four types, Tamino Incised, Mojica Impressed: Laguna Variety, Tola Trichrome, and Carrillo Polychrome, were represented in Operation B but not in Operation E. It should be noted, however, that the total number of sherds from these types is very small, making it difficult to draw any conclusions from their distribution.

Lithics

We recovered a total of 49 ground- and polished stone artifacts and fragments from Operation E (Chaps. 12 and 13). The twenty-three metate fragments include two plates with cylindrical supports, two cylindrical supports, and two conical supports. Other artifacts consist of fourteen mano fragments, three straight-bit celts and four celt fragments, a fragment of a slate mirror back, three

grinding stones, and a nutting stone. With the exception of the three celts from Burial 3, all of the ground stone artifacts come from the dense deposit of artifacts on top of the stone feature.

The well-made bar mano fragments and pieces of undecorated metates are suggestive of a household assemblage, but the slate disk fragment suggests the presence of "elite" items. No ground stone fragments fit together, suggesting that they represent artifacts broken elsewhere and discarded on top of the mortuary feature. If the artifacts were broken during activity associated with the burials, they must have been widely scattered over unexcavated parts of the feature.

The 100% sample of lithic artifacts from Operation E include numerous cooking stones and pieces of heat-cracked rock (Chap. 11). We recovered these artifacts from hearths and other domestic assemblages at sites in the Arenal basin, and their presence suggests that a portion of the assemblage from Operation E consists of waste materials from domestic activities.

Interpretations

The concentration of ceramics in Operation E appears to have been the result of both on-site smashing of whole vessels and the disposal of previously broken ones (Chap. 10). The ground stone assemblage consists exclusively of broken fragments from incomplete artifacts, scattered widely across the feature. Flaked lithics represent a large quantity of domestic debitage, probably brought to the burial complex for disposal.

Botanical Remains

We found carbonized macrobotanical remains from Operation E in the material deposited on top of the layer of large stones. They consist of a carbonized fragment of an unidentified fruit and numerous samples of carbonized wood of unknown species. Unlike the sample from Operation B, which includes some remains of maize, Operation E yielded no direct evidence of this cultigen.

Discussion

We have interpreted the large stone feature in Operation E as a mortuary complex dating to the Late Arenal Phase. The nature of the feature suggests a special regard for those interred there. The transport of heavy stones from the streambed of a

nearby *quebrada* indicates a substantial investment of energy—more than what is likely to have been undertaken by just one or two individuals. As noted earlier, however, the feature was not for the benefit of a single individual and the "compartmental" nature of the stone enclosures suggests that it does not represent a single episode of burial activity. Instead, the community or a single family may have utilized it at intervals. The deposition of materials over time was complex. As new burials were added, ceramic and lithic debris was either placed or redeposited between and within the tombs. Although sherds were found throughout the feature, however, the scatter of lithics and ceramics directly on top of the stones appears to represent a final dedicatory event. After all of the burials were in place, whether constructed all at once or by accretion, large stones and then a layer of vessels were thrown onto the feature and it was not used again.

INTRAREGIONAL COMPARISONS

The stone mortuary complex shares a number of important parallels with other contemporaneous sites in the Northwestern Cordillera region. Burial mounds constructed of river cobbles and rounded boulders have been recorded at Hacienda Jericó (Finch 1982–1983), Hacienda Mojica (Ryder 1982–1983a), Guayabo de Bagaces (Ryder 1982–1983b), and at Sitio Méndez in the Naranjo River/Bijagua Valley (Norr 1982–1983). In all of these locations, mounds appear both alone and in groups. They are frequently associated with petroglyphs. Human skeletal remains were found in burials within stone mounds at Guayabo de Bagaces and Sitio Méndez on the Naranjo River. At all of these sites, the principal occupations and mound construction took place during the mid- to late Zoned Bichrome Period, especially the last part (cal AD 300–600).

The most similar features were identified at Sitio Méndez, where one of six large mounds was trenched to reveal several burials (ibid.: 138–140). As in Operation E, a cluster of mortuary features built of large river cobbles was overlain by a deposit of crushed vessels. Ten burial pits surrounded by cobbles were identified. Four contained fragmentary skeletal remains of adults. As at Sitio Bolívar, burial offerings were rare. The only artifact recovered from any of the pits was a large jar of the type Mojica Impressed—also the most common decorated type in Sitio Bolívar assemblages.⁴

Similar features were excavated at Sitio Murillo, in the Guayabo de Bagaces region southwest of Miravalles Volcano (Ryder 1982–1983b). Large boulders and a layer of medium-sized (10–40 cm diameter) rocks formed a small, oval mound. Three "rock cluster features" built from combinations of columnar basalt pillars, thick stone slabs, thin lajas, and river cobbles within the mound were found to contain fragmentary skeletal remains. No grave goods were present. The ceramic assemblage at Sitio Murillo is similar to that from Sitio Bolívar, and Ryder suggests a date of around cal AD 300 (ibid.: 126).

Other similar features were excavated at El Carmen (or Hacienda Mojica; Ryder 1982–1983a: 106–110), a site with several stone burial mounds. Excavations exposed part of one mound, all of another, and the area between the two. A rich assemblage of seventy whole or nearly complete ceramic vessels was recovered from caches lacking skeletal remains. Burials were marked by alignments of large stones and two caches of ceramics were covered by large stones overlain in turn by a layer of sherds.

In one mound, six caches were associated with parallel lines of cobbles below a "cap" of large stones. Four of these yielded a total of seventeen ceramic vessels. Associated ceramics were Late Arenal Phase types, including two vessels of Carillo Polychrome from a cache and fragments of a Carillo bowl interpreted as a postburial offering, either placed or smashed in situ. A second set of stone alignments was associated with a rectangular tomb containing three simple metates, a mano, and half of a Las Palmas Red-on-Beige jar (an Early Arenal Phase type).⁵

Unlike Sitio Méndez, Mound 2 at El Carmen appears to have been built in stages. On the basis of the ceramics, Ryder (1982–1983a: 112) suggests that there were two or three principal phases of mound construction. The first, characterized by the tomb containing the Palmas Red-on-Beige vessel, is believed to represent the middle of the Zoned Bichrome Period (300 cal BC–cal AD 300). The second, given the appearance of Carillo Polychrome, probably dates to the latter half of the Late Arenal Phase, around cal AD 300–600.

Apart from the features at Sitio Bolívar, we did not identify large stone mounds in our own survey of the perimeter of Lake Arenal. It is possible that volcanic tephra and associated soil formation have buried or obscured stone mounds throughout much of the Arenal basin. Aguilar (1984: 82) reports a buried mound of river cobbles that was

exposed by bulldozing at the site of Río Chiquito (G-176), where tephra deposits can be several meters deep. He estimates that the mound was approximately 40 m in diameter and 3 m high, comparable in size to examples at Hacienda Jericó, Hacienda Mojica (El Carmen), and Guayabo de Bagaces. Ceramic collections at the mound yielded late Zoned Bichrome types in association with Carillo Polychrome, as was noted at both El Carmen and Sitio Bolívar. Aguilar (ibid.: 81) also reports two or three heavily looted cobble mounds at Sitio Carmelo, near the Piedras River at the western end of the lake. The associated ceramics include Corrida and Arrastrada varieties of Mojica Impressed and help tie this site chronologically to Sitio Bolívar.

Ryder (1982–1983b: 127) notes that the wide variety of burial features from sites in and near the Cordillera de Guanacaste illustrates the complexity and diversity of mortuary practices in the region during the latter half of the Zoned Bichrome Period. While there is a wide diversity in the number and size of mound features, however, the use of stone burial features appears to have been a strong cultural tradition throughout the Cordillera around cal AD 300–500. Elements of mortuary features at Sitio Bolívar, such as cobble and boulder construction, thick deposits of sherds and broken vessels, burial pits marked by alignments of standing stones, and a relative paucity of burial offerings, are similar to those found in the larger mounds. These characteristics are also geographically distinct within the Cordillera. Stone burial mounds are not associated with Zoned Bichrome cemeteries in the Tempisque Valley (Baudez 1967), the Nicoya Peninsula (Guerrero 1982–1983), or the Pacific Coast of Guanacaste (Lange 1980b, 1984b). They are also unknown in the Rivas region of Nicaragua (Healy 1980).

The stone mounds at Sitio Bolívar have more parallels in the Atlantic Watershed region than they do in the west. El Bosque Phase (AD 0–500) burials are typically constructed of large river cobbles, and include a form known as the "corridor tomb," in which grave goods and burials are placed between long rows of cobbles (Snarskis 1978: 169, 1981a: 50) in a fashion similar to that noted at El Carmen (Ryder 1982–1983a: fig. 7.2).

Theories about the nature of social organization associated with Zoned Bichrome burial mounds are linked to the question of whether these features were built during a single construction effort or by accretion. Ryder proposes that the large mound at Sitio Murillo contains as

many as one hundred tombs and was built in a single episode. Further, this might have required the direction of "an individual or group of special status" (1982–1983b:127). Norr, however, interprets the Sitio Méndez mound as "a continuous, family or community effort as individuals were added to the cemetery throughout the occupation of the site" (1982–1983:139).

To date, there is little evidence to support or refute either model. It is possible that both interpretations are correct, and that there was significant regional variation in social organization or mortuary practices in eastern Guanacaste during the Zoned Bichrome Period. In our view, the burials at Sitio Bolívar are probably best interpreted as an example of Norr's accretional model for mound construction.

All of the stone mortuary features that have been excavated contained multiple tombs, and none of them have been found to be particularly lavish in either their construction or the nature of burial offerings. In fact, despite *huaqueros'* (looters') reports of jades, ornamental metates, and elaborate ceramics from the mounds (Ryder 1982–1983b:124), very few artifacts of any kind have been recovered from these features in controlled excavations—with the exception of El Carmen. The "wealthiest" burials, such as those represented by Cache 1 at El Carmen (Ryder 1982–1983a:107), which contained fourteen ceramic vessels, or Cache 2, which contained two vessels of Carillo Polychrome in association with a large carved tripod metate and four other vessels, are not especially impressive as "chiefly" interments. While the use of basalt columns or large, volcanic *lajas* in tomb construction indicates the expenditure of a fair amount of energy, it is not beyond what one might expect from a single-family unit.

With the possible exception of the mound at Sitio Murillo, there is little evidence for centrally administrated construction in northwestern Costa Rica during the Zoned Bichrome Period. Burial patterns within the mounds themselves have not indicated the hierarchy one would expect for an elite-sponsored mortuary compound. The paucity of grave goods makes the internal chronology of burials in these features difficult to assess, and until we have further data it is probably wise to take a conservative stance on the value of stone mounds as evidence for political centralization. While we can see the beginnings of rank in the variable amounts of energy expended in tomb construction and in the accumulation of goods included in individual burials, evidence for powerful chiefs has yet to be found in these features.

DATING FEATURES AND ASSEMBLAGES

The features and assemblages at Sitio Bolívar have been dated by means of comparisons with material from similar sites in northwestern Costa Rica and new radiocarbon dates. The chronological placement of prehistoric activities at Sitio Bolívar is useful not only for reconstructing cultural development in the Arenal basin, but also for understanding patterns that characterize the Zoned Bichrome Period in both the Cordillera and the Greater Nicoya regions.

We obtained five radiocarbon dates from excavations in both the lakeshore and the ridge top portions of Sitio Bolívar. The earliest, 770 (399) 200 cal BC (Tx-5271: 390 BC \pm 170), comes from a possible hearth at the base of deposits in Operation B. It suggests that Sitio Bolívar was utilized during the Early Arenal Phase, although few ceramics from this phase were present.⁶ A second date of cal AD 261 (398) 435 (Tx-5273: AD 290 \pm 70) from the sherd midden and a third of cal AD 567 (642) 669 (Tx-5270: AD 540 \pm 80) from the matrix of the stone tomb features in Operation E date activities during the principal Late Arenal occupation of the site. A date of cal AD 145 (244) 338 (Tx-5272: 180 AD \pm 60) was obtained from one of the two firepits (A8) on the lakeshore. The latter half of its range is consistent with the estimated dates for the principal occupation of Sitio Bolívar. The second firepit (A9) yielded a date of cal AD 879 (894) 975 (Tx-5269: AD 820 \pm 50). It is several hundred years too late and does not overlap the date of the first firepit even with a two-sigma interval. We believe this second sample to have been contaminated.

On the basis of interpretations of a corpus of radiocarbon dates from related contexts and assemblages elsewhere in Costa Rica, the principal occupation of Sitio Bolívar is dated to cal AD 300–600, during which time both the mortuary features on the ridge top and the habitational features on the lakeshore are believed to have been constructed. At this time, the site was quite large relative to other sites in the Arenal basin. Both macrobotanical remains and ground stone artifacts such as manos and metates indicate the cultivation and processing of maize, but there is also evidence for a continued exploitation of tree crops such as palm fruits and *nance* (*Byrsonima crassifolia*). Long-distance contacts with areas to both the east and the west are suggested by Atlantic Watershed ceramics and greenstone pendants of imported materials. The association of a slate mirror back with mortuary features in Operation

E suggests the possibility of down-the-line trade from Mesoamerican cultures much farther to the north. These have also been found at the site of La Fortuna, just east of Arenal Volcano (Stone and Balser 1965), where they were associated with a ceramic assemblage very similar to that of Sitio Bolívar and dated to AD 300–500 (Baudez and Coe 1966).

The period of Sitio Bolívar's principal occupation coincides roughly with the Early Classic Period in the Maya Lowlands, during which time Classic Maya trade with the southeastern "periphery" was at its peak (Hoopes 1984b). Costa Rican contact with Mesoamerica at this time might have included a loose network for the procurement of jadeite from southern Guatemala (Lange and Bishop 1982–1983). Contact between Mesoamerican cultures and the Cordillera region, however, appears to have been confined to the exchange of small trinkets such as slate mirror backs and occasional incised jades. Neither the appearance of more elaborate burial architecture nor the level of sociopolitical complexity associated with its construction suggests strong cultural influence from Mesoamerica.

CONCLUSIONS

Sitio Bolívar is interpreted as the remains of a Late Arenal Phase village. Lakeshore and ridge top investigations indicate activities associated with both life and death in this community. The site appears to have been spatially organized with houses situated on a flat bench near a freshwater stream (now mostly inundated by the waters of Lake Arenal) and a cemetery on top of the ridge overlooking the site.

The features located on the shore of Lake Arenal at Sitio Bolívar are distinctly domestic in appearance. The circular patterns of postholes; the presence of firepits with charcoal, fire-cracked rock and large numbers of cooking stones; and the fact that vessels from this part of the site consist primarily of large jars for storage and cooking indicate that this portion of the site served as the locus for household activities, especially the preparation of food.

Unfortunately, given the narrow strip of shoreline and the problem of erosion since the lake's recent filling, we cannot infer numbers of dwellings or the size of the total habitation area. We do know, however, that structures were circular in plan and variable in size. We have estimated the internal areas of the two structures identified on

the lakeshore at approximately 7 m² and 24 m². The larger one probably represents a family dwelling and the smaller one a special-function structure such as a sweat bath or a storage space. Most of the dwellings were probably located in a portion of the site that has been inundated by Lake Arenal. Water to the north of the exposed shoreline is fairly shallow, especially as one approaches the lagoon at the mouth of Quebrada Bolívar. This broad area of relatively flat ground would have been ideal for settlement. The habitational features that we were able to identify we interpret as the remains of the village that was served by the hilltop cemetery.

One of the most interesting characteristics of the lakeshore features is that they suggest the existence of round houses at Arenal Phase sites. This pattern indicates the continuation of a tradition established during the Tronadora Phase, as evidenced by the remains of structures at Tronadora Vieja (Chap. 4). At present, dwellings have not been reported from any other Zoned Bichrome sites in northwestern Costa Rica. The Sitio Bolívar structures, however, suggest that Late Arenal Phase architecture was distinct from contemporaneous El Bosque Phase structures in the Atlantic Watershed region. Snarskis (1984b) notes that El Bosque houses were rectangular, with foundations made of river cobbles. Citing a round/circular dichotomy between Mesoamerican and South American architectural traditions in the Formative Period, Snarskis attributes the rectangular shape of El Bosque houses to Mesoamerican influence that accompanied the introduction of intensive maize agriculture. He also notes a shift from rectangular to circular structures in the Atlantic Watershed/Central Highlands regions around AD 500. According to our evidence from the Arenal basin, the rectangular house form tradition did not extend to the Northwestern Cordillera region.

The contemporaneity of the occupation of the two areas of the site is clearly indicated by the associated ceramics. Although there is a higher percentage of decorated types in the ridge top cemetery, pottery from the lakeshore is identical to that associated with the mortuary features. As noted earlier, all of the features date to the latter part of the Late Arenal Phase, most likely between cal AD 300–600 (see also Chap. 10). Strata on which the major lakeshore occupation occurred had largely eroded away; however, it seems likely that the lakeshore features—like those elsewhere at the site—originated in Unit 54 and penetrated the Aguacate Formation.

We found no evidence of habitations during testing in the ridge top portion of Sitio Bolívar, which appears to have served a primarily mortuary function. The combination of both midden and mortuary features in this part of the site suggests that the ridge top was considered unsuitable for either dwellings or agriculture and was used for the disposal of both people and artifacts. The location of Zoned Bichrome cemeteries on the tops of hills and ridges is a common pattern in Guanacaste (Lange and Scheidenhelm 1972), and the choice of this type of setting for the cemetery at Sitio Bolívar is further evidence that Arenal Phase peoples were participating in cultural traditions characteristic of Greater Nicoya.

The feature in Operation B appears to represent a secondary deposition of material from surrounding burials, perhaps in conjunction with burials of individuals of lower social rank or with smaller families than those buried under the large stone features in Operation E. The group of enclosures of large river cobbles capped with heavy boulders in Operation E is interpreted as the remains of a funerary mound constructed by higher-ranking individuals or families.

The large quantities of broken ceramics and other artifacts found in association with these features are suggestive of the rites and ceremonies that may have accompanied Late Arenal Phase interments. Large feasts in conjunction with funerals are common to a number of cultures (Huntington and Metcalf 1979) and can include ritual vessel smashing. At La Ceiba, a site on the Tempisque River dating to the late Middle Polychrome Period (cal AD 800–1300), such activities are evidenced by a large complex of elongated clay ovens and huge quantities of faunal and floral remains in association with burials (Blanco et al. 1986: 149). Unlike at La Ceiba, however, there is no evidence that the cooking of funeral feasts occurred on or near the burials at Sitio Bolívar.

It is possible that the artifacts on top of the mortuary features were the personal possessions of the interred. Smashing and depositing them on top of the burials would have removed the objects of the deceased from common use—the psychological equivalent of placing them in the grave. This could explain both the domestic nature of the artifact deposit and the paucity of offerings within the tombs themselves. As a practice similar to the burning of the house of a dead relative, the smashing and destruction of vessels would have helped to remove traces of the deceased's mortal existence from the community.

The destruction of objects that had been the property of the deceased has been reported from similar contexts. At the site of El Carmen (Hacienda Mojica), Ryder (1982–1983a: 107) reports a contemporaneous burial cache of fourteen vessels, most of which had been ritually “killed” by punching holes in their bases. As noted earlier, deposits of broken pottery on mortuary features are common in the Northwestern Cordillera of Costa Rica.

An alternative explanation for this pattern is that cemeteries and tombs were considered appropriate locations for disposing of broken artifacts. Just as burial practices removed deceased individuals from the principal habitation areas, trash heaps and sherd middens would have removed broken vessels from paths and other areas in daily use. In addition, broken vessels served as both offerings to dead relatives and markers for grave locations. It seems likely that the features represent a cemetery that experienced relatively intensive use in a short amount of time, and that burial practices necessitated the frequent displacement of both soil and artifacts in and on it.

The features at Sitio Bolívar provide us with a glimpse of what village life was like in the Arenal basin at the end of the Late Formative Period. Late Zoned Bichrome society at the site appears to have had an economy based on both maize horticulture and the collection of wild foods. Social organization was probably organized along the lines of kinship, but evidence for centralized leadership is lacking. The similarities in ceramic styles and mortuary practices that Sitio Bolívar shares with other sites in both the Arenal basin and the Northwestern Cordillera region suggest participation in a more widespread, regional “culture,” possibly maintained through intercommunity exchange networks and regional religious sodalities.

Understanding the nature of village life at sites like Sitio Bolívar is important for addressing problems concerning the nature of sociopolitical organization and the emergence of rank in lower Central America. At Sitio Bolívar, the only evidence for social ranking lies in the appearance of imported objects such as greenstone pendants and slate mirror backs and the differentiation between simple burials covered with sherds (Operation B) and more elaborate burials covered with both stones and sherds. Because evidence for chiefly individuals and centralized political authority is missing, it is difficult to substantiate an interpretation that Zoned Bichrome society was organized along the lines of chiefdoms (See Habicht-

Mauche et al. 1987; Hoopes 1988). There is clear artifactual evidence, however, that Arenal Phase peoples were actively participating in a network of communication (and probably exchange) that stretched westward into Greater Nicoya. This interaction, as well as the construction of stone burial mounds, was probably carried out in the context of a decentralized political organization. Understanding the nature of prehistoric society at villages like Sitio Bolívar can provide us with important insights into the emergence of ranking and complex *tribes*—as opposed to chiefdoms—in lower Central America.

NOTES

1. A detailed description of investigations at this site can also be found in Hoopes 1987: 98–161.
2. Features are identified by individual lot numbers.
3. Although other material was grouped in separate lots, it is likely that *all* of it derives from this feature.
4. Norr (1982–1983: 143) notes that ceramics from the stone “cap” of the Méndez mound were similar to collections from an unidentified stone burial mound near Arenal.
5. A large charcoal sample from this tomb yielded a date of 349 cal BC—cal AD 42 (UCLA-2167E: 160 BC ± 80; Ryder 1982–1983a: 109). Its association with a vessel of Las Palmas Red-on-Beige makes this feature contemporaneous with the Early Arenal Phase, about 300 years earlier than the principal occupation at Sitio Bolívar.
6. This date is very close to that of a sample dated to 394–207 cal BC (UCLA-2163: 300 BC ± 60) from the base of a similar mound excavated by Norr (1982–1983: 140) at Sitio Méndez.

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Arenal Region,
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References Cited

- ABEL-VIDOR, S.
1980 The Historical Sources for the Greater Nicoya Archaeological Sub-Area. *Vinculos* 6(1-2):155-169.
1981 Ethnohistorical Approaches to the Archaeology of Greater Nicoya. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*. Edited by E. Benson, pp. 85-92. New York: Harry N. Abrams.
1988 Gonzalo Fernández de Oviedo y Valdés: His Work and His Nicaragua, 1527-1529. In *Costa Rican Art and Archaeology: Essays in Honor of Frederick R. Mayer*. Edited by Frederick W. Lange, pp. 261-290. Boulder: University of Colorado.
- ABEL-VIDOR, S., C. BAUDEZ, R. BISHOP, L. BONILLA V., M. CALVO M., W. CREAMER, J. DAY, J. GUERRERO, P. HEALY, J. HOOPES, F. LANGE, S. SALGADO, R. STROESSNER, AND A. TILLET
1987 Principales tipos cerámicos y variedades de la Gran Nicoya. *Vinculos* 13(1-2):35-318.
- ACCOLA, RICHARD
1978 Una revisión de los tipos de cerámica del período policromo medio en Guanacaste. *Vinculos* 4:80-105.
- ADAMS, RICHARD E. W.
1977 *Prehistoric Mesoamerica*. Boston: Little, Brown and Co.
- AGUILAR P., C.
1972 *Guayabo de Turrialba*. San José: Editorial Costa Rica.
1976 Relaciones de las culturas precolombianas en el intermontano central de Costa Rica. *Vinculos* 2(1):75-86.
1984 Introducción a la arqueología de la región del volcán Arenal. *Anales, Academia de Geografía e Historia de Costa Rica* (San José).
- ALLEN, KAREN E.
1948 Lauraceae. Flora of Panama. Part V. Fascicle 1. *Annals of the Missouri Botanical Garden* 35:2-5.
- ALLEN, PAUL H.
1977 *The Rain Forests of Golfo Dulce*. Stanford, Calif.: Stanford University Press.

- ANDERSON, W. R.
1983 Byrsonima crassifolia [Nance, Nancite, Shoemaker's tree]. In *Costa Rican Natural History*. Edited by Daniel Janzen, pp. 202-204. Chicago: University of Chicago Press.
- ANDREWS V., E. WILLEYS, AND NORMAN HAMMOND
1990 Redefinition of the Swasey Phase at Cuello, Belize. *American Antiquity* 55(3):570-584.
- BALSER, CARLOS
1974 *El jade de Costa Rica*. San José: Librería Lehmann.
- BARKLEY, FRED A.
1934 The Statistical Theory of Pollen Analysis. *Ecology* 15(3):283-289.
- BARTLETT, ALEXANDRA S., AND ELSON S. BARGHOORN
1973 Phytogeographic History of the Isthmus of Panama during the Past 12,000 Years. In *Vegetation and Vegetational History of Northern Latin America*. Edited by Alan H. Graham, pp. 203-299. New York: Elsevier Scientific Publishing Co.
- BAUDEZ, CLAUDE F.
1967 Recherches archéologiques dans la vallée du Tempisque, Guanacaste, Costa Rica. *Travaux et Mémoires de l'Institut des Hautes Etudes de l'Amérique Latine*, no. 18. Centre National de la Recherche Scientifique, Paris.
- BAUDEZ, CLAUDE F., AND MICHAEL D. COE
1962 Archaeological Sequences in Northwestern Costa Rica. Akter, 34th International Congress of Americanists, pp. 366-373. Vienna.
- 1966 Incised Slate Disks from the Atlantic Watershed of Costa Rica: A Commentary. *American Antiquity* 31:441-443.
- BERNSTEIN, DAVID
1980 Artefactos de piedra pulida de Guanacaste, Costa Rica: una perspectiva funcional. *Vinculos* 6(1-2):141-154.
- BINFORD, L. R.
1971 Mortuary Practices: Their Study and Their Potential. In *Approaches to the Social Dimensions of Mortuary Practices*. Edited by J. A. Brown, pp. 6-29. *Memoirs of the Society for American Archaeology*, no. 25.
- 1972 *An Archaeological Perspective*. Seminar Press, New York.
- BISCHOF, HENNING
1966 Canapote—an Early Ceramic Site in Northern Colombia. Preliminary Report. *Actas y Memorias, 36 1/2 Congreso Internacional de Americanistas* 1:484-491. Seville.
- 1972 The Origins of Pottery in South America: Recent Radiocarbon Dates from Southwest Ecuador. *Proceedings of the 40th International Congress of Americanists* 1:269-281. Genoa: Tilgher.
- BISHOP, RONALD L., F. W. LANGE, AND P. C. LANGE
1988 Ceramic Paste Compositional Patterns in Greater Nicoya Pottery. In *Costa Rican Art and Archaeology*. Edited by F. W. Lange, pp. 11-44. Boulder: University of Colorado Museum.
- BLACK, KEVIN D.
1983 The Zapotitán Valley Archeological Survey. In *Archaeology and Volcanism in Central America*. Edited by Payson D. Sheets, pp. 62-97. Austin: University of Texas Press.
- BLANCO VARGAS, AIDA M., JUAN VICENTE GUERRERO MIRANDA, AND SILVIA SALGADO GONZÁLEZ.
1986 Patrones funerarios del policromo medio en el sector sur de Gran Nicoya. *Vinculos* 12(1-2):135-158.
- BLANTON, RICHARD E.
1972 Prehispanic Settlement Patterns of the Ixtapalapa Peninsula Region, Mexico. *Occasional Papers of the Department of Anthropology*, no. 6. University Park: The Pennsylvania State University.
- BLONG, RUSSELL J.
1984 *Volcanic Hazards: A Sourcebook on the Effects of Eruptions*. New York: Academic Press.
- BORGIA, A., C. POORE, M. CARR, W. MELSON, AND G. ALVARADO
1988 Structural, Stratigraphic, and Petrologic Aspects of the Arenal-Chato Volcanic System, Costa Rica: Evolution of a Young Stratovolcanic Complex. *Bulletin of Volcanology* 50:86-105.
- BOUCHER, D. H., M. HANSEN, S. RISCH, AND J. H. VANDERMEER
1983 Agriculture; Introduction. In *Costa Rican Natural History*. Edited by Daniel H. Janzen, pp. 66-73. Chicago: University of Chicago Press.
- BOZARTH, S.
1986 Morphologically Distinctive Phaseolus, Cucurbita, and Helianthus Phytoliths. In *Plant Opal Phytolith Analysis in Archaeology and Paleocology*. Edited by I. Rovner, pp. 56-66. Occasional Papers No. 1 of the Phytolitharian, North Carolina State University.
- BOZZOLI DE WILLIE, MARIA EUGENIA
1975 Birth and Death in the Belief System of the Bribri Indians of Costa Rica. Ph.D. dissertation (Anthropology), University of Georgia, Athens.
- BRADLEY, JOHN
1984 The Silencio Funerary Sites. *Vinculos* 10(1-2):93-114.
- BRADLEY, JOHN E., JOHN E. HOOPES, AND PAYSON SHEETS
1984 Lake Site Testing Program. *Vinculos* 10(1-2):75-92.
- BRAY, WARWICK
1978 An Eighteenth-Century Reference to a Fluted Point from Guatemala. *American Antiquity* 43:457-460.
- 1981 Gold Work. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*. Edited by E. Benson, pp. 153-166. New York: Harry N. Abrams.
- 1984 Across the Darien Gap: A Colombian View of Isthmian Archaeology. In *The Archaeology of Lower Central America*. Edited by F. W. Lange and D. Z. Stone, pp. 305-340. Albuquerque: University of New Mexico Press.
- BRUSH, C. F.
1965 Pox Pottery: Earliest Identified Mexican Ceramic. *Science* 149:194-195.
- 1969 A Contribution to the Archeology of Costal Guerrero, Mexico. Ph.D. Dissertation, Columbia University.
- BRYANT, VAUGHN M., JR., AND RICHARD G. HOLLOWAY
1983 The Role of Palynology in Archaeology. In *Advances in Archaeological Method and Theory*, Vol. 6. Edited by Michael D. Schiffer, pp. 191-224. Orlando: Academic Press.
- BURTON, I., R. KATES, AND G. WHITE
1978 *The Environment as Hazard*. New York: Oxford University Press.
- CAMERON, H. L.
1958 History from the Air. *Photogrammetric Engineering* 24:366-375.
- CAPPER, COL. J. E.
1907 Photographs of Stonehenge as Seen from a War Balloon. *Archaeologia*:571.
- CARLSON, JOHN B.
1981 Olmec Concave Iron-Ore Mirrors: The Aesthetics of a Lithic Technology and the Lord of the Mirror. In *The Olmec and Their Neighbors*. Edited by Elizabeth P. Benson, pp. 117-148. Washington, D.C.: Dumbarton Oaks Research Library and Collections, Trustees for Harvard University.
- CARR, M. J., AND I. A. WALKER
1987 Intra-eruption Changes in the Composition of Some Mafic to Intermediate Tephra in Central America. *Journal of Volcanic and Geothermal Research* 33:147-159.
- CARSON, M. A., AND M. J. KIRKBY
1972 *Hillslope Form and Process*. Cambridge: Cambridge University Press.
- CARSTENS, K. C., T. C. KIND, AND N. V. WEBER
1982 Using Remote Sensing in a Predictive Model: The Jackson Purchase Region, Kentucky. *Proceedings of Pecora VII Symposium*, pp. 494-507. Washington, D.C.: U.S. Dept. of the Interior.
- CASTILLO-MUÑOZ, R.
1983 Geology. In *Costa Rican Natural History*. Edited by Daniel Janzen, pp. 47-62. Chicago: University of Chicago Press.
- CATER, JOHN D.
n.d. Groundstone Artifacts from Site 5MT2, Yellow Jacket, CO. Manuscript. University of Colorado Museum, Boulder.
- CHACÓN, JUAN BRAVO
1982 Geomorfología de la Hoja Fortuna. Trabajo de Investigación para el Grado de Licenciado en Geografía. Campus Omar Dengo, Heredia, Costa Rica.
- CHANG, K. C.
1968 Toward a Science of Prehistoric Society. In *Settlement Archaeology*. Edited by K. C. Chang, pp. 1-9. Palo Alto, Calif.: National Press.
- CHAPMAN, R.
1981 The Emergence of Formal Disposal Areas and the "Problem" of Megalithic Tombs in Prehistoric Europe. In *The Archaeology of Death*. Edited by R. Chapman, I. Kinnes, K. Randsborg, pp. 71-81. Cambridge: Cambridge University Press.
- CHENAULT, MARK L.
1984a Ground and Polished Stone from the Cuenca de Arenal. *Vinculos* 10(1-2):167-186.
- 1984b Test Excavations at Neblina and Las Piedras. *Vinculos* 10(1-2):115-120.
- 1986 Technical Analysis of Precolumbian Costa Rican Jadeite and Greenstone Artifacts. M.A. thesis, University of Colorado.
- 1988 Jadeite, Greenstone and the Precolumbian Costa Rican Lapidary. In *Costa Rican Art and Archaeology: Essays in Honor of Frederick R. Mayer*. Edited by Frederick W. Lange, pp. 89-110. Boulder: University of Colorado.
- CHENAULT, M., AND M. MUELLER
1984 Jewelry from the Cuenca de Arenal. *Vinculos* 10(1-2):187-192.
- CHIESA, S.
1987 Estudio de las capas piroclásticas (tefras) del Volcán Arenal (Costa Rica) con énfasis en la Unidad 20. Report no. 276, Instituto Costarricense de Electricidad.
- CLARK, JOHN E., MICHAEL BLAKE, PEDRO GUZY, MARTA CUEVAS, AND TAMARA SALCEDO
n.d. Final Report to the Instituto Nacional de Antropología e Historia of the Early Preclassic Pacific Coastal Project. Manuscript. New World Archaeological Foundation, Brigham Young University.
- CLARY, KAREN H.
1986 An Analysis of Pollen from Core 2, from the Nacacolo Archaeological Area, on the Nicoya Peninsula, Northwestern Costa Rica. Manuscript. University Museum of Archaeology/Anthropology, University of Pennsylvania, Philadelphia.
- In prog. Pollen Studies from Coastal Cores from the Bay of res. Parita, Panama.
- COE, MICHAEL D.
1960 Archaeological Linkages with North and South America at La Victoria, Guatemala. *American Anthropologist* 62:363-393.
- 1961 La Victoria, an Early Site on the Pacific Coast of Guatemala. *Papers of the Peabody Museum of Archaeology and Ethnology*, vol. 53. Cambridge: Harvard University.
- COE, MICHAEL D., AND C. BAUDEZ
1961 The Zoned Bichrome Period in Northwestern Costa Rica. *American Antiquity* 26:505-515.
- COE, MICHAEL D., AND RICHARD DIEHL
1980 *In the Land of the Olmec*. Austin: University of Texas Press.
- COE, MICHAEL D., AND KENT V. FLANNERY
1967 Early Cultures and Human Ecology in South Coastal Guatemala. *Smithsonian Contributions to Anthropology*, vol. 3. Washington, D.C.: Smithsonian Institution.
- CONANT, F. P.
1976 Satellite Analysis of Human Ecosystems in the Sahel of East Africa. Proposal submitted to the National Science Foundation.
- CONANT, F. P., AND T. K. CARY
1977 A First Interpretation of East Africa Swiddening Via Computer-assisted Analysis of 3 Landsat Tapes. *Proceedings, 1977, Machine Processing of Remotely Sensed Data Symposium*, pp. 36-43. West Lafayette, Ind.: Purdue University.
- COOKE, R.
1984 Archaeological Research in Central and Eastern Panama: A Review of Some Problems. In *The Archaeology of Lower Central America*. Edited by F. Lange and D. Stone, pp. 263-302. Albuquerque: University of New Mexico Press.
- COOKE, R. G., AND A. J. RANERE
1984 The Proyecto Santa María: A Multidisciplinary Analysis of Prehistoric Adaptations to a Tropical Watershed in Panama. In *Recent Developments in Isthmian Archaeology: Advances in the Prehistory of Lower Central America*. Edited by Frederick W. Lange, pp. 1-30. Proceedings of the 44th Congress of Americanists, Manchester, 1982. B.A.R. Series 212.

- CORRALES, FRANCISCO U.
1985 Prospección y excavaciones estratigráficas en el Sitio Curré (P-62-Ce), Valle Diquis, Costa Rica. *Vínculos* 11(1-2):1-16.
- 1989 La ocupación agrícola temprana del sitio arqueológico Curré, Valle del Diquis. Tesis de Lic., Escuela de Antropología y Sociología, Facultad de Ciencias Sociales, Universidad de Costa Rica, San José.
- CRAWFORD, O. G. S.
1923 Air Survey and Archaeology. *Geographical Journal* 61:342-366.
- 1924a Archaeology from the air. *Nature* 114:580-582.
- 1924b Air Survey and Archaeology. *Ordinance Survey Professional Papers*, no. 7.
- 1929 Air Photography for Archaeologists. *Ordinance Survey Professional Papers*, no. 12.
- CRAWFORD, O. G. S., AND ALEXANDER KEILLER
1928 *Wessex from the Air*. Oxford: Clarendon Press.
- CREAMER, WINIFRED
1979 Preliminary Survey Near Upala (Alajuela), Costa Rica. Paper Presented at the 44th Annual Meeting, Society for American Archaeology, Vancouver.
- 1983 Production and Exchange on Two Islands in the Gulf of Nicoya, Costa Rica, A.D. 1200-1550. Ph.D. dissertation, Tulane University. Ann Arbor: University Microfilms.
- CREAMER, W., AND S. DAWSON
1982- Preliminary Survey near Upala, Alajuela, Costa Rica. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):161-166.
- 1983 Tribe versus Chiefdom in Lower Central America. *American Antiquity* 50:738-754.
- CREAMER, W., AND J. HAAS
1985
- CROAT, THOMAS B.
1978 *Flora of Barro Colorado Island*. Stanford, Calif.: Stanford University Press.
- CRUMLEY, CAROLE L.
1983 Archaeological Reconnaissance at Mont Dardon, France. *Archaeology* (May-June):12-17.
- DAHLGREN, B. E.
1936 Index of American Palms. In *Field Museum of Natural History Botanical Series* 14(35):406-409.
- DAHLIN, B. H.
1980 Surveying the Volcán Region with the Post Hole Digger. In *Adaptive Radiations in Prehistoric Panama*, pp. 276-279. Peabody Museum Monograph 5. Cambridge: Harvard University.
- DAY, I. S.
1984 New Approaches in Stylistic Analysis: The Late Polychrome Period Ceramics from Hacienda Tempisque, Guanacaste Province, Costa Rica. Ph.D. dissertation, University of Colorado. Ann Arbor: University Microfilms.
- DECKER, R. W., AND D. HADIKUSUMO
1961 Results of the 1960 Expedition to Krakatau. *Journal of Geophysical Research* 66:3497-3511.
- DENEVAN, WILLIAM M.
1961 The Upland Pine Forests of Nicaragua. *University of California Publications in Geography* 12(4):251-320.
- DEUEL, LEO
1969 *Flights into Yesterday: The Story of Aerial Archaeology*. New York: St. Martin's Press.
- DILLON, BRIAN D.
1984 Island Building and Villages of the Dead: Living Archaeology in the Comarca de San Blas, Panama. *Journal of New World Archaeology* 6(2):49-65.
- DROLET, ROBERT P.
1983 Al otro lado de Chiriqui, El Diquis: nuevos datos para la integración cultural de la región Gran Chiriqui. *Vínculos* 9(1-2):25-76.
- 1984a Investigations in Diquis. In *The Archaeology of Lower Central America*. Edited by Frederick W. Lange and Doris Stone, pp. 33-60. Albuquerque: University of New Mexico Press.
- 1984b Community Life in a Late Phase Agricultural Village, Southeastern Costa Rica. In *Recent Developments in Isthmian Archaeology: Advances in the Prehistory of Lower Central America*. Edited by Frederick W. Lange, pp. 123-152. Proceedings of the 44th Congress of Americanists. B.A.R. Series 212, Manchester.
- EARLE, T., AND A. W. JOHNSON
1982 Research and Technology: Annual Report Fiscal Year 1982. National Space Technology Laboratories, National Aeronautics and Space Administration. NSTL Station.
- 1987 *The Evolution of Human Societies: From Foraging Group to Agrarian State*. Stanford, Calif.: Stanford University Press, Stanford Earth Resources Laboratory.
- EASBY, ELIZABETH K.
1968 *Pre-Columbian Jade from Costa Rica*. New York: Andre Emmerich.
- 1981 Jade. In *Between Continents/Between Seas: Pre-Columbian Art of Costa Rica*. Edited by E. Benson, pp. 135-151. New York: Harry R. Abrams.
- EBERT, JAMES
1984 Remote Sensing Applications in Archaeology. In *Advances in Archaeological Method and Theory*, vol. 7. Edited by Michael B. Schiffer, pp. 293-362. Orlando, Fla.: Academic Press.
- EBERT, JAMES, AND THOMAS R. LYONS
1983 Archaeology, Anthropology, and Cultural Resources Management. In *Manual of Remote Sensing*. Edited by Robert N. Colwell, pp. 1233-1304. Vol. II, Interpretation and Applications. Falls Church, Va.: American Society of Photogrammetry.
- EDIENE, BERNARD
1956 Une Méthode pratique pour la detection aeriene des sites archaeologiques, en particulier par la photographie sur films en couleurs et sur films infrarouges. *Bulletin de la Société Préhistorique Française* 53:540-546.
- EIDT, R. C.
1984 *Advances in Abandoned Settlement Analysis: Application to Prehistoric Anthrosols in Colombia, South America*. Milwaukee: University of Wisconsin-Milwaukee, Center for Latin America.
- EINHAUS, C. SHELTON
1980 Stone Tools from La Pitahaya (IS-3). In *Adaptive Radiations in Prehistoric Panama*. Edited by Olga Linares and Anthony Ranere, pp. 429-466. Peabody Museum Monograph 5. Cambridge: Harvard University, Peabody Museum.
- ERDTMAN, G.
1952 *Pollen Morphology and Plant Taxonomy. Angiosperms*. Waltham, Mass.: Chronica Botanica Co.
- FANALE, R.
1974 Utilization of ERTS-1 Imagery in the Analysis of Settlement and Land Use of the Dogon of Mali. M.S. thesis (Anthropology), Catholic University.
- FERRERO, A. L.
1977 *Costa Rica Precolombina*. San José: Editorial Costa Rica.
- 1981 *Costa Rica Precolombina*. 4th edition. San José: Editorial Costa Rica.
- FINCH, WILL O.
1982- A Preliminary Survey of Hacienda Jericó. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):97-104.
- FINDLOW, FRANK J., M. J. SNARSKIS, AND P. MARTIN
1979 Un análisis de zonas de explotación relacionadas con algunos sitios prehistóricos de la vertiente atlántica de Costa Rica. *Vínculos* 5(2):53-71.
- FLANNERY, KENT, ED.
1976 *The Early Mesoamerican Village*. New York: Academic Press.
- FLANNERY, KENT, AND JOYCE MARCUS
1983 *The Cloud People: Divergent Evolution of the Zapotec and Mixtec Civilizations*. New York: Academic Press.
- FONSECA Z., OSCAR
1981 Guayabo de Turrialba and Its Significance. In *Between Continents/Between Seas: Pre-Columbian Art of Costa Rica*. Edited by E. Benson, pp. 104-111. New York: Harry N. Abrams.
- FORD, JAMES A.
1969 A Comparison of Formative Cultures in the Americas: Diffusion or the Psychic Unity of Man? *Smithsonian Institution Contributions to Anthropology*, vol. 2. Washington, D.C.: Smithsonian Institution.
- FORD, RICHARD I.
1984 Prehistoric Phytogeography of Economic Plants in Latin America. In *Pre-Columbian Plant Migration*. Edited by Doris Stone, pp. 175-183. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 76.
- FOSHAG, WILLIAM
1957 Mineralogical Studies on Guatemalan Jade. *Smithsonian Miscellaneous Collections* 145(5).
- FRIEDMAN, I., AND J. GLEASON
1984 C¹³ Analysis of Bone Samples from Site G-150, El Silencio. *Vínculos* 10(1-2):113-114.
- FUDALL, R., AND W. G. MELSON
1972 Ejecta Velocities, Magma Chamber Pressure, and Kinetic Energy Associated with the 1968 Eruption of Arenal Volcano, Costa Rica. *Bulletin Volcanologique* 35(2):383-401.
- GALINAT, W. C.
1980 The Archaeological Maize Remains from Volcan Panama—A Comparative Perspective. In *Adaptive Radiations in Prehistoric Panama*. Edited by Olga Linares and Anthony Ranere, pp. 175-180. Peabody Museum Monograph 5. Cambridge: Harvard University, Peabody Museum.
- GARNETT, D. (ED.)
1938 *The Letters of T. E. Lawrence*. London: Spring Books.
- GEOLOGICAL SOCIETY OF AMERICA
1948 *Goddard Rock Color Chart*. Boulder: Geological Society of America.
- GOLDSTEIN, LYNNE
1981 One-Dimensional Archaeology and Multi-Dimensional People: Spatial Organization and Mortuary Analysis. In *The Archaeology of Death*. Edited by R. Chapman, I. Kinnes, K. Ransborg, pp. 53-69. Cambridge: Cambridge University Press.
- GRAHAM, MARK
1981 Traditions of Costa Rican Stone Sculpture. In *Between Continents/Between Seas: Pre-Columbian Art of Costa Rica*. Edited by E. Benson, pp. 113-134. New York: Harry N. Abrams.
- GREEN, DEE F., AND GARETH W. LOWE
1967 Altamira and Padre Piedra, Early Preclassic Sites in Chiapas, Mexico. *Papers of the New World Archaeological Foundation*, no. 20.
- GUERRERO, J.
1982- Recientes investigaciones en el Valle de Nosara,
1983 Guanacaste. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):369-386.
- GUERRERO, J., AND A. BLANCO
1987 La Ceiba: un asentamiento del policromo medio en el Valle del Tempisque con actividades funerarias. Thesis (Anthropology and Sociology), University of Costa Rica, San José.
- GUERRERO, J., A. BLANCO, AND S. SALGADO
1986 "Patrones funerarios del policromo medio en el sector sur de Gran Nicoya." *Vínculos* 12:135-157.
- GUMERMAN, GEORGE J., AND JAMES A. NEELY
1972 An Archaeological Survey of the Tehuacán Valley, Mexico: A Test of Color Infrared Photography. *American Antiquity* 37:520-527.
- HABERLAND, WOLFGANG
1966 Early Phases on Ometepe Island. *Actas y Memorias, 36 1/2 Congreso Internacional de Americanistas* 1:399-403.
- 1969 Early Phases and Their Relationship in Southern Central America. *Proceedings and Transactions of the 38th International Congress of Americanists* 1:229-242.
- 1978 Lower Central America. In *Chronologies in New World Archaeology*. Edited by R. E. Taylor and C. W. Meighan, pp. 395-430. New York: Academic Press.
- 1982- Settlement Patterns and Cultural History of Ometepe Island, Nicaragua: A Preliminary Sketch. In
1983 *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):369-386.
- 1983 To Quench the Thirst: Water and Settlement in Central America. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*. Edited by E. Vogt and R. Levanthal, pp. 79-88. Albuquerque and Cambridge: University of New Mexico and Peabody Museum Press.
- HABICHT-MAUCHE, JUDITH, JOHN W. HOOPES, AND MICHAEL GESELOWITZ
1987 Where's the Chief?: The Archaeology of Complex Tribes. Paper Presented at the 52nd Annual Meeting of the Society for American Archaeology, Toronto, May 6-10.
- HAGGETT, PETER
1965 *Locational Analysis in Human Geography*. London: Arnold.

- HAMMOND, NORMAN, DUNCAN PRING, RICHARD WILK, SONA DONAGHEY, FRANK P. SAUL, ELIZABETH S. WING, ARLENE V. MILLER, AND LAWRENCE H. FELDMAN
1979 The Earliest Lowland Maya? Definition of the Swasey Phase. *American Antiquity* 44(1):92-110.
- HARNER, MICHAEL J.
1970 Population Pressure and the Social Evolution of Agriculturalists. *Southwestern Journal of Anthropology* 26: 1-106.
- HARRIS, D.
1973 The Prehistory of Tropical Agriculture: An Ethnoecological Model. In *The Explanation of Culture Change*. Edited by C. Renfrew, pp. 391-417. London: Duckworth.
- HARTMAN, C.
1901 *Archaeological Researches in Costa Rica*. Stockholm: Royal Ethnographical Museum.
1907 *Archaeological Researches on the Pacific Coast of Costa Rica*. *Memoirs, Carnegie Museum*, no. 3.
- HARTSHORN, G.
1983 Plants: Introduction. In *Costa Rican Natural History*. Edited by D. Janzen, pp. 118-157. Chicago: University of Chicago Press.
- HEALY, PAUL
1974 *Archaeological Survey of the Rivas Region, Nicaragua*. Ph.D. dissertation (Anthropology), Harvard University.
1980 *Archaeology of the Rivas Region, Nicaragua*. Waterloo, Ontario: Winfred Laurier University Press.
1988 Greater Nicoya and Mesoamerica: Analysis of Selected Ceramics. In *Costa Rican Art and Archaeology*. Edited by F. W. Lange, pp. 291-302. Boulder: University of Colorado Museum.
- HEIZER, ROBERT F., AND JONAS E. GULLBERG
1981 Concave Mirrors from the Site of La Venta, Tabasco: Their Occurrence, Mineralogy, Optical Description, and Function. In *The Olmec and Their Neighbors*. Edited by Elizabeth P. Benson, pp. 109-116. Washington, D.C.: Dumbarton Oaks Research Library and Collections, Trustees for Harvard University.
- HELMS, M.
1979 *Ancient Panama: Chiefs in Search of Power*. Austin: University of Texas Press.
- HERTZ, ROBERT
1960 *Death and the Right Hand*. Translated by Rodney and Claudia Needham. Glencoe, Ill.: Free Press.
- HESTER, T.
1986 On the Misuse of Projectile Point Typology in Mesoamerica. *American Antiquity* 51:412-415.
- HEUSSER, CALVIN J.
1971 *Pollen and Spores of Chile*. Tucson: University of Arizona.
- HOOPEES, J.
1979 Recent Archaeological Investigations at the Site of La Guinea, Tempisque River Valley, Guanacaste, Costa Rica. B.A. thesis, Yale University.
1980 Archaeological Investigations at the Site of La Guinea, Tempisque River Valley, Guanacaste, Costa Rica. ms on file, National Museum of Costa Rica.
1984a A Preliminary Ceramic Sequence for the Cuenca de Arenal, Cordillera de Tilarán Region, Costa Rica. *Vinculos* 10(1-2): 129-148.
1984b Prehistoric Habitation Sites in the Río Santa Rosa Drainage. *Vinculos* 10(1-2): 121-128.
- 1985 El Complejo Tronadora: cerámica del período formativo en el cuenca de Arenal, Guanacaste, Costa Rica. *Vinculos* 11(1-2): 111-118.
- 1987 Early Ceramics and the Origins of Village Life in Lower Central America. Ph.D. dissertation (Anthropology), Harvard University. Ann Arbor: University Microfilms.
- n.d. Early Formative Cultures in the Intermediate Area: A Background to the Emergence of Social Complexity. Manuscript.
- 1988 The Complex Tribe in Prehistory: Sociopolitical Organization in the Archaeological Record. Paper presented at the 53rd Annual Meeting of the Society for American Archaeology, Phoenix, April 27-May 1.
- HORDER, ALAN (ED.)
1971 *The Manual of Photography*. Philadelphia: Chilton.
- HORTON, R. E.
1945 Erosional Development of Streams and Their Drainage Basins: Hydrophysical Approaches to Quantitative Morphology. *Bulletin of the Geological Society of America* 56: 275-370.
- HUMMER, ANNE G.
1983 Ground Stone of the Zapotitán Valley. In *Archaeology and Volcanism in Central America*. Edited by Payson D. Sheets, pp. 229-253. Austin: University of Texas Press.
- HUNTINGTON, RICHARD, AND PETER METCALF
1979 *Celebrations of Death: The Anthropology of Mortuary Rituals*. New York: Cambridge University Press.
- IMESON, A. C., AND M. VIS
1982 Factors Influencing the Erodibility of Soils in Natural and Semi-Natural Ecosystems at Different Altitudes in the Central Cordillera of Colombia. In *Applied Geomorphology in the Tropics*. Edited by I. Douglas and T. Spencer, pp. 91-106. Berlin: Gebruder.
- JANZEN, DANIEL H.
1983 *Crescentia alata* (Jicaro, Guacal, Gourd tree). In *Costa Rican Natural History*. Edited by Daniel H. Janzen, pp. 222-224. Chicago: University of Chicago Press.
- JENSEN, JOHN R.
1986 *Introductory Digital Image Processing: A Remote Sensing Perspective*. Englewood Cliffs, N.J.: Prentice-Hall.
- JESSUP, T.
1981 Why Do Apo Kayan Shifting Cultivators Move? *Borneo Research Bulletin* 13(1): 16-32.
- JOYCE, A.
1983 *Remote Sensing of Forest Dynamics in Tropical Regions*. Washington, D.C.: NASA Office of Space Science and Applications.
- KAHLE, A. B., AND A. F. H. GOETZ
1983 Mineralogic Information from a New Airborne Thermal Infrared Multispectral Scanner. *Science* 222: 24-27.
- KAPP, RONALD O.
1969 *Pollen and Spores*. Dubuque, Ia.: Wm. C. Brown.
- KENNEDY, WILLIAM J.
1968 Archaeological Investigations in the Reventazón River Drainage Area, Costa Rica. Ph.D. dissertation (Anthropology), Tulane University.
- KIDDER, A. V.
1929 Air Exploration of the Maya Country. *Bulletin of the Pan American Union* 63: 1200-1205.
1930a Colonel and Mrs. Lindbergh Aid Archaeologists. *Masterkey* 3(6): 5-17.
1930b Five Days over the Maya Country. *Scientific Monthly* 30: 193-205.
- KIDDER, A. V., JESSE D. JENNINGS, AND EDWIN M. SHOOK
1946 *Excavations at Kaminaljuyu, Guatemala*. Carnegie Institution of Washington, Publication 561. Washington, D.C.
- KIRKBY, M. J.
1969 Erosion by Water on Hillslopes. In *Introduction to Fluvial Processes*. Edited by Richard Chorley, pp. 229-238. Suffolk: Mithuen.
- KNIGHTLEY, P., AND C. SIMPSON
1971 *The Secret Lives of Lawrence of Arabia*. New York: Bantam Books.
- LANGE, F.
1971 *Culture History of the Sapoa River Valley, Costa Rica*. Occasional Papers in Anthropology, no. 4. Beloit, Wisc.: Logan Museum, Beloit College.
1976 Bahías y valles de la Costa de Guanacaste. *Vinculos* 2: 45-66.
1978 Coastal Settlement in Northwestern Costa Rica. In *Coastal Adaptations: The Economy of Maritime Middle America*. Edited by B. Stark and B. Voorhies, pp. 101-119. New York: Academic Press.
1980a The Formative Zoned Bichrome Period in Northwestern Costa Rica (800 BC to AD 500), Based on Excavations at the Vidor Site, Bay of Culebra. *Vinculos* 6(1-2): 33-42.
1980b Una ocupación del policromo tardío en sitio Ruiz, cerca de Bahía Culebra. *Vinculos* 6(1-2): 81-96.
1982-1983 The Guanacaste/San Carlos Corridor Project. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2): 93-96.
1984a Cultural Geography of Pre-Columbian Lower Central America. In *The Archaeology of Lower Central America*. Edited by F. Lange and D. Stone, pp. 33-60. Albuquerque: University of New Mexico Press.
1984b The Greater Nicoya Archaeological Subarea. In *The Archaeology of Lower Central America*. Edited by F. Lange and D. Stone, pp. 165-194. Albuquerque: University of New Mexico Press.
- LANGE, F. (ED.)
1980c *Vinculos*, Vol. 6. Special issue on the Bahía Culebra Area, Guanacaste.
- LANGE, F., AND S. ABEL-VIDOR
1980 The Formative Zoned Bichrome Period in Northeastern Costa Rica (800 BC to AD 500). *Vinculos* 6: 33-42.
- LANGE, F., S. ABEL-VIDOR, CLAUDE F. BAUDEZ, RONALD L. BISHOP, WINIFRED CREAMER, JANE S. DAY, JUAN VICENTE GUERRERO M., PAUL F. HEALY, SILVIA SALGADO G., ROBERT STROESSNER, AND ALICE TILLET
1984 New Approaches to Greater Nicoya Ceramics. In *Recent Developments in Isthmian Archaeology: Advances in the Prehistory of Lower Central America*. Edited by F. W. Lange. Proceedings of the 44th International Congress of Americanists. Manchester, 1982. B.A.R. International Series 212: 199-214 [Oxford].
- LANGE, F., AND RICHARD M. ACCOLA
1979 Metallurgy in Costa Rica. *Archaeology* 32(5): 26-33.
- LANGE, F., AND RONALD L. BISHOP
n.d. Papers of the Greater Nicoya Ceramic Conference Manuscript, Smithsonian Institution.
1982-1983 A Search for Jade Sources and Prehistoric Settlement on the Santa Elena Peninsula. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. Lange and L. Norr. *Journal of the Steward Anthropological Society*, vol. 14, nos. 1 and 2. University of Illinois, Urbana.
- LANGE, F., AND T. MURRAY
1972 Archeology of the San Dimas Valley, Costa Rica. *Katunob* 7(4): 50-91.
- LANGE, F., AND L. NORR (EDS.)
1982-1983 *Prehistoric Settlement Patterns in Costa Rica*. *Journal of the Steward Anthropological Society*, vol. 14, nos. 1 and 2. University of Illinois, Urbana.
- LANGE, F., AND C. RYDBERG
1972 Abandonment and Post-Abandonment Behavior at a Rural Central American House-Site. *American Antiquity* 37(3): 419-431.
- LANGE, F., AND K. SCHEIDENHELM
1972 The Salvage Archaeology of a Zoned Bichrome Cemetery. *American Antiquity* 37(2): 240-245.
- LANGE, F., AND D. STONE (EDS.)
1984 *The Archaeology of Lower Central America*. Albuquerque: University of New Mexico Press.
- LAWRENCE, GEORGE H. M.
1951 *Taxonomy of Vascular Plants*. New York: Macmillan.
- LEÓN, JORGE
1968 *Fundamentos botánicos de los cultivos tropicales*. San Jose: Instituto Interamericano de Ciencias Agrícolas de la O.E.A.
- LEOPOLD, E. G., AND R. A. SCOTT
1957 Pollen and Spores and Their Use in Geology. *Annual Report of the Smithsonian Institution* 1957: 303-323.
- LEYDEN, BARBARA
1987 Man and Climate in the Maya Lowlands. *Quaternary Research* 28: 407-414.
- LILLESAND, THOMAS M., AND RALPH W. KIEFER
1979 *Remote Sensing and Image Interpretation*. New York: John Wiley and Sons.
- LINARES, O., AND A. RANERE (EDS.)
1980 *Adaptive Radiations in Prehistoric Panama*. Peabody Museum Monograph 5. Cambridge: Harvard University.
- LINARES, O., AND P. SHEETS
1980 Highland Agricultural Villages in the Volcán Baru Region. In *Adaptive Radiations in Prehistoric Panama*. Edited by O. Linares and A. Ranere, pp. 44-55. Peabody Museum Monographs, no. 5. Cambridge: Harvard University.
- LINARES, O., P. SHEETS, AND J. ROSENTHAL
1975 Prehistoric Agriculture in Tropical Highlands. *Science* 187(4172): 137-145.
- LIND, A.
1981 Applications of Aircraft and Satellite Data for the Study of Archaeology and Environment, Mekong Delta, Vietnam. In *International Symposium on Remote Sensing of Environment*, Proceedings, vol. 3: 1529-1537.

- LINDBERGH, C. A.
1929 The Discovery of Ruined Maya Cities. *Science* 70:12-13.
- LINES, JORGE A.
1936 Una huaca en Zapandí. Notas preliminares tomadas a propósito de las excavaciones arqueológicas hechas a raíz de la inundación del Río Tempisque en 1933, Filadelfia, Provincia de Guanacaste, Península de Nicoya, Costa Rica. San José: Imprenta Lehmann.
- LOTHROP, SAMUEL K.
1926 *Pottery of Costa Rica and Nicaragua*. Contributions from the Museum of the American Indian, no. 8. 2 vols. New York: Heye Foundation.
- 1950 Archaeology of Southern Veraguas, Panama. *Memoirs of the Peabody Museum of Archaeology and Ethnology* 9(3). Cambridge: Harvard University Press.
- 1963 Archaeology of the Diquis Delta, Costa Rica. *Papers of the Peabody Museum of Archaeology and Ethnology*, vol. 51. Cambridge: Harvard University.
- 1966 Archaeology of Lower Central America. In *Archaeological Frontiers and External Connections*. Edited by Gordon R. Willey and Gordon F. Ekholm, pp. 180-208. *Handbook of Middle American Indians, Volume 4*. Austin: University of Texas Press.
- LOWE, GARETH W.
1959 Archaeological Exploration of the Upper Grijalva River, Chiapas, Mexico. *Papers of the New World Archaeological Foundation*, no. 2.
- 1971 The Civilizational Consequences of Varying Degrees of Agricultural and Ceramic Dependency within the Basic Ecosystem of Mesoamerica. In *Observations on the Emergence of Civilization in America*. Edited by Robert F. Heizer and John A. Graham, pp. 212-248. Contributions of the University of California Research Facility, no. 11:212-248. Berkeley and Los Angeles: University of California Press.
- 1975 The Early Preclassic Barra Phase of Altamira, Chiapas: A Review with New Data. *Papers of the New World Archaeological Foundation*, no. 38.
- 1978 Eastern Mesoamerica. In *Chronologies in New World Archaeology*. Edited by R. E. Taylor and C. W. Meighan, pp. 331-393. New York: Academic Press.
- LYONS, T. R., AND T. W. AVERY
1977 *Remote Sensing: A Handbook for Archeologists and Cultural Resource Managers*. Washington, D.C.: National Park Service.
- MACARTHUR, R. H.
1972 *Geographical Ecology: Patterns in the Distribution of Species*. New York: Harper and Row.
- MACNEISH, RICHARD S., ANTOINETTE NELKEN-TERNER, AND IRMGARD W. JOHNSON
1967 *The Prehistory of the Tehuacán Valley, Vol. 2: Nonceramic Artifacts*. Austin: University of Texas Press.
- MACNEISH, RICHARD S., F. A. PETERSON, AND K. V. FLANNERY
1970 *The Prehistory of the Tehuacán Valley, Vol. 3: Ceramics*. Austin: University of Texas Press.
- MACNEISH, RICHARD S., JEFFERY K. WILKERSON, AND ANTOINETTE NELKEN-TERNER
1980 *First Annual Report of the Belize Archaic Archaeological Reconnaissance*. Andover, Mass.: Robert E. Peabody Foundation for Archaeology, Phillips Academy.
- MADRY, SCOTT L. H.
1983 Remote Sensing in Archaeology. *Archaeology* (May-June): 18-20.
- MALAVASSI, E.
1979 Geology and Petrology of Arenal Volcano. M.A. thesis, University of Hawaii.
- MARKGRAF, VERA, AND HECTOR L. D'ANTONI
1978 *Pollen Flora of Argentina*. Tucson: University of Arizona Press.
- MARTIN, P. S., AND J. SCHOENWETTER
1960 Arizona's Oldest Cornfield. *Science* 132:33-34.
- MASON, J. ALDEN
1927 Mirrors of Ancient America. *The Museum Journal* 18(2):201-209. Museum of the University of Pennsylvania, Philadelphia.
- 1945 Costa Rican Stonework: The Minor C. Keith Collection. *Anthropological Papers of the American Museum of Natural History* 39.
- MATTHEWS, MEREDITH H.
1984 Results of Macrobotanical Analysis for the Proyecto Prehistórico Arenal: Preliminary Evidence of Resource Use and Subsistence Strategies. *Vinculos* 10(1-2):193-205.
- MCK. BIRD, ROBERT
1984 South American Maize in Central America. In *Pre-Columbian Plant Migration*. Edited by Doris Stone, pp. 39-66. *Papers of the Peabody Museum of Archaeology and Ethnology*, vol. 76.
- MEGERS, BETTY J., CLIFFORD EVANS, AND EMILIO ESTRADA
1965 Early Formative Period of Coastal Ecuador. *Smithsonian Institution Contributions to Anthropology*, vol. 1. Washington, D.C.: Smithsonian Institution.
- MEHRINGER, P. I.
1967 Pollen Analysis on the Tule Springs Site, Nevada. In *Pleistocene Studies in Southern Nevada*. Edited by H. M. Wormington and D. Ellis, pp. 130-200. Carson City: Nevada State Museum Anthropological Papers 13.
- MELÉNDEZ, CARLOS
1984 Papel de los Zopilotes en la religión de los indios del Pacífico Sur de Costa Rica. In *Vº Centenario de Gonzalo Fernández de Oviedo, Memoria del Congreso sobre el Mundo Centroamericano de su Tiempo*, pp. 79-87. San José, Costa Rica: Editorial Texto Ltda.
- MELSON, W.
1978 Eruption of Arenal Volcano, Costa Rica, 1968-1973. *National Geographic Society Research Reports*, pp. 433-446.
- 1982 Alternation between Basaltic Andesite and Dacite in Historic and Prehistoric Eruptions for Arenal Volcano, Costa Rica. Manuscript. Washington, D.C.: Smithsonian Institution.
- 1984 Prehistoric Eruptions of Arenal Volcano, Costa Rica. *Vinculos* 10:35-59.
- MELSON, W., J. BARQUERO, R. SAENZ, AND E. FERNÁNDEZ
1986 Erupciones explosivas de importancia en volcanes de Costa Rica. *Boletín Volcanología* 16:15-22.
- MELSON, W., AND R. SAENZ
1968 The 1968 Eruption of Arenal Volcano, Costa Rica: Preliminary Summary of Field and Laboratory Studies. November 7, report. Smithsonian Institution Center for Short-lived Phenomena.
- 1973 Volume, Energy, and Cyclicity of Eruptions of Arenal Volcano, Costa Rica. *Bulletin Volcanologique* 37(3):416-437.
- MELTZER, D. J., D. D. FOWLER, AND J. A. SABLOFF (EDS.)
1986 *American Archaeology Past, Present, and Future*. Washington, D.C.: Society for American Archaeology and Smithsonian Institution Press.
- MINAKAMI, T., S. UTIBORI, AND S. HIRAGA
1969 The 1968 Eruption of Volcano Arenal, Costa Rica. *Bulletin of Earthquake Research* 47:783-808.
- MUELLER, MARILYNN
1984a Laguna de Arenal Shoreline Survey. *Vinculos* 10(1-2):61-74.
- 1984b Appendix A. The Silencio Stratigraphic Sequence. *Vinculos* 10(1-2):51-55.
- 1986 Settlement in the Cuenca de Arenal, Northwestern Costa Rica. M.A. thesis, University of Colorado.
- MURRAY, THOMAS A., AND EDWARD W. JESS
1976 Preliminary Report of the Río Sabalo Valley Survey. Manuscript, Dept. of Anthropology, SUNY, Binghamton.
- MYERS, THOMAS P.
1978 Formative Period Interaction Spheres in the Intermediate Area: Archaeology of Central America and Adjacent South America. In *Advances in Andean Archaeology*. Edited by D. L. Browman. The Hague: Mouton.
- NEWHALL, C. G., AND W. MELSON
1983 Explosive Activity Associated with the Growth of Volcanic Domes. *Journal of Volcanic and Geothermal Research* 17:111-131.
- NOLAN, MARY LEE
1979 Impact of Paricutin on Five Communities. In *Volcanic Activity and Human Ecology*. Edited by P. Sheets and D. Grayson, pp. 293-338. New York: Academic Press.
- NORDENSKIÖLD, ERLAND
1926 Miroirs convexes et concaves en Amérique. *Journal de la Société des Americanistes de Paris* 18:103-110.
- NORR, LYNETTE
1979 Stone Burial Mounds and Petroglyphs of the Zoned Bichrome Period. Paper presented at the 44th Annual Meeting of the Society for American Archaeology, Vancouver.
- 1982- Archaeological Site Survey and Burial Mound
1983 Excavations in the Río Naranjo-Bijagua Valley. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society*, vol. 14: 135-156.
- NORWEB, ALBERT
1964 Ceramic Stratigraphy in Southwestern Nicaragua. *Proceedings and Transactions of the 35th International Congress of Americanists* 1:551-561.
- ODIO, EDUARDO
1989 La Pochota: un sitio temprano en el Valle de Tempisque. Manuscript, Museo Nacional, San José.
- PASZTORY, ESTHER
1983 *Aztec Art*. New York: Henry N. Abrams.
- PEARSALL, D. M.
1989 *Paleoethnobotany: A Handbook of Procedures*. San Diego: Academic Press.
- PEARSON, G. W., J. R. PILCHER, M. G. L. BAILLIE, D. M. CORBETT, AND F. QUA
1986 High-Precision C¹⁴ Measurement of Irish Oaks to Show the Natural C¹⁴ Variations from AD 1840-5210 BC. *Radiocarbon* 28(2B):911-934.
- PEARSON, G. W., AND M. STUIVER
1986 High-Precision Calibration of the Radiocarbon Time Scale, AD 1950-500 BC. *Radiocarbon* 28(2B): 805-838.
- PERALTA, M. M.
1883 *Costa Rica, Nicaragua y Panamá en el siglo XVI. su historia y sus límites según los documentos de archivo de las Indias de Sevilla, del Simancas, etc., recogidos y publicados con notas y aclaraciones históricas y geográficas*. Madrid: Librería de M. Murillo.
- PIPERNO, D.
1984 A Comparison and Differentiation of Phytoliths from Maize and Wild Grasses: Use of Morphological Criteria. *American Antiquity* 49:361-383.
- 1985a Phytolith Analysis and Tropical Paleo-Ecology: Production and Taxonomic Significance of Siliceous Forms in New World Plant Domesticates and Wild Species. *Review of Paleobotany and Palynology* 45:185-228.
- 1985b Phytolith Taphonomy and Distributions in Archaeological Sediments from Panama. *Journal of Archaeological Science* 12:247-267.
- 1985c Phytolith Analysis of Geological Sediments from Panama. *Antiquity* 59:13-19.
- 1988 *Phytolith Analysis: An Archaeological Perspective*. San Diego: Academic Press.
- PIPERNO, D., AND V. STARCZAK
1985 Numerical Analysis of Maize and Wild Grass Phytoliths Using Multivariate Techniques. Paper presented at the 2nd Phytolith Research Workshop, Duluth.
- PLOG, FRED
1968 Archaeological Surveys: A New Perspective. M.A. thesis, University of Chicago.
- POSEY, D.
1983 Indigenous Ecological Knowledge and Development in the Amazon. In *The Dilemma of Amazonian Development*. Edited by E. Moran, pp. 225-257. Boulder, Colo.: Westview Press.
- FRANCE, GHILLEAN T.
1984 The Peñibaye, Guilielma gasipaes (H.B.K) Bailey, and the Papaya, *Carica papaya* L. In *Pre-Columbian Plant Migration*. Edited by Doris Stone. *Papers of the Peabody Museum of Archaeology and Ethnology* 76:85-104.
- RECORD, SAMUEL J., AND ROBERT W. HESS
1943 *Timbers of the New World*. New Haven: Yale University Press.
- REES, J.
1979 Effects of the Eruption of Paricutin Volcano on Landforms, Vegetation, and Human Occupancy. In *Volcanic Activity and Human Ecology*. Edited by P. Sheets and D. Grayson, pp. 249-292. New York: Academic Press.

- REICHEL-DOLMATOFF, GERARDO
1955 Excavaciones en los conchales de la costa de Barlovento. *Revista Colombiana de Antropología* 4: 249-272.
- 1965a *Columbia. Ancient Peoples and Places*. New York: Praeger.
- 1965b *Excavaciones arqueológicas en Puerto Hormiga, Departamento de Bolívar*. Publicaciones de la Universidad de Los Andes, Antropología 2 (Bogotá).
- 1985 *Monsú: un sitio arqueológico*. Bogotá: Fondo de Promoción de la Cultura del Banco Popular.
- REINING, P.
1973 *Utilization of ERTS-1 Imagery in Cultivation and Settlement Site Identification and Carrying Capacity Estimates in Upper Volta and Niger*. Springfield, Va.: National Technical Information Center.
- 1974a Human Settlement Patterns in Relation to Resources of Less Developed Countries. *Proceedings: COSPAR Meetings*, São Paulo, Brazil. On file at International Office, American Association for the Advancement of Science, Washington, D.C.
- 1974b Use of ERTS-1 Data in Carrying Capacity Estimates for Sites in Upper Volta and Niger. Paper presented at the 1974 Annual Meeting of the American Anthropological Association, Mexico City.
- RICHARDS, P.
1966 *The Tropical Rain Forest: An Ecological Study*. Cambridge: Cambridge University Press.
- RICHARDSON, FRANCIS B.
1940 Non-Maya Monumental Sculpture of Central America. In *The Maya and Their Neighbors*. Edited by C. L. Hay et al., pp. 395-416. New York: D. Appleton-Century.
- RICKETSON, OLIVER, JR., AND A. V. KIDDER
1930 An Archeological Reconnaissance by Air in Central America. *Geographical Review* 20(2).
- RITTER, DALE F.
1986 *Process Geomorphology*. Dubuque, Ia.: W. C. Brown.
- ROWE, JOHN HOWLAND
1953 Technical Aids in Anthropology: A Historical Survey. In *Anthropology Today*. Edited by Alfred L. Kroeber, pp. 895-940. Chicago: University of Chicago Press.
- RYDER, PETER
1982-1983a Hacienda Mojica. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):105-120.
- 1982-1983b Guayabo de Bagaces. In *Prehistoric Settlement Patterns of Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):121-134.
- SABINS, FLOYD F., JR.
1987 *Remote Sensing: Principles and Interpretation*. 2d ed. New York: W. H. Freeman.
- SABLOFF, J. A., AND R. E. SMITH
1969 The Importance of Both Analytic and Taxonomic Classification in the Type-Variety System. *American Antiquity* 34(3):278-285.
- SAENZ, R.
1976 Erupción del Volcán Arenal en el año 1968. *Revista Geográfica de América Central* 5: 149-188.
- SAENZ, R., AND W. MELSON
1976 La erupción del Volcán Arenal, Costa Rica en julio, 1968. *Revista Geográfica de América Central* 5:55-148.
- SAXE, A.
1970 Social Dimensions of Mortuary Practices. Ph.D. dissertation, University of Michigan. Ann Arbor: University Microfilms.
- SCHIFFER, MICHAEL D.
1987 *Formation Processes of the Archaeological Record*. Albuquerque: University of New Mexico Press.
- SCHWONGERDT, R.
1983 *Techniques for Image Processing and Classification in Remote Sensing*. London: Academic Press.
- SEGERSTROM, K.
1950 *Erosion Studies at Paricutin*. U.S. Geological Survey Bulletin 965-A. Washington, D.C.: Government Printing Office.
- SEVER, T., AND J. WISEMAN
1985 Conference on Remote Sensing: Potential for the Future. Manuscript. NASA Earth Resources Library Report, NSTL Station, Miss.
- SHARER, R. (ED.)
1978 *The Prehistory of Chalchuapa, El Salvador*. 3 vols. Philadelphia: University of Pennsylvania Press.
- SHAZLY, E. M.
1983 Space Borne Imagery Interpretation of Mega Features Related to Egyptian Archeology. *International Geoscience and Remote Sensing Symposium*, vol. 1. New York: Institute of Electrical and Electronic Engineers.
- SHEETS, PAYSON D.
1978 Artifacts. In *The Prehistory of Chalchuapa, El Salvador*, vol. 2. Edited by R. Sharer, pp. 2-133. Philadelphia: University of Pennsylvania Press.
- 1982-1983 Preliminary Reconnaissance of the Cuenca de Arenal 1981-1982. In *Prehistoric Settlement Patterns in Costa Rica*. Edited by F. W. Lange and L. Norr. *Journal of the Steward Anthropological Society* 14(1-2):157-159.
- 1983 Settlement, Subsistence, and Volcanism near Arenal, Costa Rica. Proposal submitted to the National Science Foundation.
- 1984a Proyecto Prehistórico Arenal, an Introduction. *Vínculos* 10(1-2):17-30.
- 1984b Chipped Stone Artifacts from the Cordillera de Tilarán. *Vínculos* 10(1-2):149-166.
- 1984c Summary and Conclusions. *Vínculos* 10(1-2):207-223.
- SHEETS, PAYSON D. (ED.)
1983 *Archeology and Volcanism in Central America: The Zapotitán Valley of El Salvador*. Austin: University of Texas Press.
- SHEETS, PAYSON D., AND M. MUELLER (EDS.)
1984 Archeological Investigations in the Cordillera de Tilarán, Costa Rica, 1984. Special issue of *Vínculos* 10(1-2).
- SHEETS, PAYSON D., E. I. ROSENTHAL, AND A. J. RANERE
1980 Stone Tools from Volcán Baru. In *Adaptive Radiations in Prehistoric Panama*. Edited by Olga F. Linares and Anthony J. Ranere, pp. 404-428. Peabody Museum Monographs No. 5. Cambridge: Harvard University.
- SIEGEL, B. S., AND A. R. GILLESPIE
1980 *Remote Sensing in Geology*. New York: Wiley.
- SMITH, C. E.
1980 Plant Remains from the Chiriqui Sites and Ancient Vegetational Patterns. In *Adaptive Radiations in Prehistoric Panama*. Edited by Olga F. Linares and Anthony J. Ranere, pp. 151-174. Peabody Museum Monographs No. 5. Cambridge: Harvard University.
- SMITH, R. E., G. R. WILLEY, AND J. C. GIFFORD
1960 The Type-Variety Concept as a Basis for the Analysis of Maya Pottery. *American Antiquity* 25(3):330-340.
- SNARSKIS, MICHAEL J.
1976 La vertiente atlántica de Costa Rica. *Vínculos* 2: 101-114.
- 1978 The Archaeology of the Central Atlantic Watershed of Costa Rica. Ph.D. dissertation, Columbia University.
- 1979 Turrialba: A Paleo-Indian Quarry and Workshop Site in Eastern Costa Rica. *American Antiquity* 44: 125-138.
- 1981a Archaeology of Costa Rica. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*. Edited by E. Benson, pp. 15-84. New York: Harry N. Abrams.
- 1981b Catalogue. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*. Edited by E. Benson, pp. 178-227. New York: Harry N. Abrams.
- 1982 *La cerámica precolombina en Costa Rica/Precolumbian Ceramics in Costa Rica*. Bilingual ed. San José: Instituto Nacional de Seguros.
- 1984a Central America: The Lower Caribbean. In *The Archaeology of Lower Central America*. Edited by F. Lange and D. Stone, pp. 195-232. Albuquerque: University of New Mexico Press.
- 1984b Prehistoric Microsettlement Patterns in the Central Highlands-Atlantic Watershed of Costa Rica. In *Recent Developments in Isthmian Archaeology*. Edited by F. Lange. B.A.R. International Series, 212:153-178 (Oxford).
- 1985 Symbolism of Gold in Costa Rica and Its Archaeological Perspective. In *The Art of Precolumbian Gold*. Edited by Julie Jones, pp. 22-33. London: Weidenfeld and Nicholson.
- SNARSKIS, MICHAEL J., AND AIDA BLANCO
1978 Dato sobre cerámica policromada guanacasteca excavada en la Meseta Central. *Vínculos* 4:106-114.
- SOUTHWARD, JUDITH
1982 Identifying Food-Preparation Activities Using Ethnographic and Archaeological Data Bases. M.A. thesis, University of Colorado, Boulder.
- SQUIER, EPHRAIM GEORGE
1860 Some Account of the Lake of Yojoa or Taulebe, in Honduras, Central America. *Journal of the Royal Geographical Society* 30: 58-63.
- STANDLEY, PAUL C.
1937 *Flora of Costa Rica*. Field Museum of Natural History, Botanical Series, vol. 18, Chicago.
- STOCKMARR, JENS
1971 Tablets with Spores Used in Absolute Pollen Analysis. *Pollen et Spores* 13(4):615-621.
- STONE, DORIS
1972 *Pre-Columbian Man Finds Central America*. Cambridge, Mass.: Peabody Museum Press.
- 1977 *Precolumbian Man in Costa Rica*. Cambridge, Mass.: Peabody Museum Press.
- STONE, DORIS, AND CARLOS BALSER
1965 Incised Slate Discs from the Atlantic Watershed of Costa Rica. *American Antiquity* 30:310-329.
- STRAUSS, JOYCE R.
n.d. A Mirror Tradition in Pre-Columbian Art. M.A. thesis, University of Denver.
- STUIVER, M., AND G. W. PEARSON
1986 High-Precision Calibration of the Radiocarbon Time Scale, AD 1950-500 BC. *Radiocarbon* 28(2B): 805-838.
- SWAUGER, JAMES L., AND WILLIAM J. MAYER-OAKES
1952 A Fluted Point from Costa Rica. *American Antiquity* 17:264-265.
- SWEENEY, JEANNE W.
1975 *Guanacaste, Costa Rica: An Analysis of Precolumbian Ceramics from the Northwest Coast*. Ph.D. dissertation [Anthropology], University of Pennsylvania. Ann Arbor: University Microfilms.
- TAINTER, I.
1973 The Social Correlates of Mortuary Patterning at Kaloko, North Koua, Hawaii. *Archeology and Physical Anthropology of Oceania* 8: 1-11.
- 1977 Modeling Change in Prehistoric Social Systems. In *Formal Theory Building in Archaeology*. Edited by L. Binford, pp. 327-351. New York: Academic Press.
- 1978 Mortuary Practices and the Study of Prehistoric Social Systems. In *Advances in Archaeological Method and Theory*, no. 1. Edited by M. B. Schiffer, pp. 105-143. New York: Academic Press.
- TARTAGLIA, LOUIS J.
1977 Infrared Archeological Reconnaissance. In *Remote Sensing Techniques in Archeology*. Edited by T. R. Lyons and R. Hitchcock, pp. 35-50. Albuquerque: Chaco Center.
- TOLSTOY, P., AND S. FISH
1975 Surface and Subsurface Evidence for Community Size at Coapexco, Mexico. *Journal of Field Archaeology* 2: 97-104.
- TOSI, I.
1980 *Estudio ecológico integral de las zonas de afectación del Proyecto Arenal*. San José: Centro Científico Tropical.
- TSUKADA, MATSUO, AND JOHN R. ROWLEY
1964 Identification of Fossil Maize Pollen. *Grana Palynologica* 5(3):406-412.
- VAILLANT, G. C.
1930 Excavations at Zacatenco. *Anthropological Papers*, vol. 32: Pt. 1. New York: American Museum of Natural History.
- VAN DER MERWE, N.
1982 Carbon Isotopes, Photosynthesis, and Archeology. *American Scientist* 70:596-606.
- VOORHIES, BARBARA
1976 The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico. *New World Archaeological Foundation Paper*, no. 41.

- WAGNER, PHILIP L.
1985 Nicoya, a Cultural Geography. *University of California Publications in Geography* 12: 193-250.
- WALLACE, HENRY, AND RICHARD M. ACCOLA
1980 Investigaciones arqueológicas preliminares de Nacascolo, Bahía Culebra, Costa Rica. *Vinculos* 6 (1-2):51-67.
- WEILAND, DORIS
1984 Prehistoric Settlement Patterns in the Santa María Drainage of Central Panama: A Preliminary Analysis. In *Recent Developments in Isthmian Archaeology: Advances in the Prehistory of Lower Central America*. Edited by F. W. Lange, pp. 31-53. Proceedings of the 44th Congress of Americanists. B.A.R. Series 212, Manchester.
- WEST, R., AND J. AUGELLI
1966 *Middle America: Its Lands and Peoples*. Englewood Cliffs, N.J.: Prentice-Hall.
- WILLEY, G.
1971 *An Introduction to American Archaeology, Volume 2: South America*. Englewood Cliffs, N.J.: Prentice-Hall.
1984 A Summary of the Archaeology of Lower Central America. In *The Archaeology of Lower Central America*. Edited by F. Lange and D. Stone, pp. 341-378. Albuquerque: University of New Mexico Press.
- WILLEY, G., W. BULLARD, J. GLASS, AND J. GIFFORD
1965 *Prehistoric Maya Settlements in the Belize Valley*. Peabody Museum Papers, vol. 54. Cambridge: Harvard University.
- WILLEY, G., AND C. R. MCGIMSEY
1954 *The Monagrillo Culture of Panama*. Peabody Museum Papers, vol. 54. Cambridge: Harvard University.
- WILLEY, G., AND J. SABLOFF
1971 *A History of American Archaeology*. San Francisco: Freeman.
- WINTER, MARCUS C.
1976 The Archaeological Household Cluster in the Valley of Oaxaca. In *The Early Mesoamerican Village*. Edited by Kent V. Flannery, pp. 25-31. New York: Academic Press.
- WU, S., AND S. SADER
1987 *Multipolarization SAR Data for Surface Feature Delineation and Forest Vegetation Characterization*. IEEE Transactions on Geoscience and Remote Sensing, vol. GE-25, no. 1. New York: Institute of Electrical and Electronic Engineers.
- YOUNG, R. A., AND C. K. MUTCHER
1969 Soil Movement on Irregular Slopes. *Water Resources Research* 5: 1084-1089.
- ZEITLIN, R.
1984 A Summary Report on Three Seasons of Field Investigations into the Archaic Period Prehistory of Lowland Belize. *American Anthropologist* 86: 359-369.
- ZEVALLOS MENÉNDEZ, CARLOS, W. C. GALINAT, D. W. LATHRAP, E. R. LENG, J. G. MARCOS, AND K. M. KLUMPP
1977 The San Pablo Corn Kernel and Its Friends. *Science* 196(4288):385-389.

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