THE TRONADORA COMPLEX: EARLY FORMATIVE CERAMICS IN NORTHWESTERN COSTA RICA

John W. Hoopes

The correlation of archaeological features with tephra stratigraphy and radiocarbon dates in the volcanic cordillera of northwestern Costa Rica has provided evidence for an Early to Middle Formative ceramic complex dating to at least 2000 B.C.[1] Tronadora ceramics have been found in association with evidence for early horticulture and sedentism. Stylistic comparisons with other early pottery from Central America have helped with the refinement of our chronology for the earliest sedentary societies in Costa Rica and Nicaragua. Differences between Tronadora pottery and the earliest complexes of Mesoamerica and southern Central America indicate a high degree of regionalization in ceramic styles during the Early Formative period. Similarities also indicate, however, the common participation of northwestern Costa Rica and southern Mesoamerica in broad interaction networks at this time. Tronadora pottery does not represent an incipient technology or the result of a diffusion of ceramic production from Mesoamerica or northwestern South America. Instead, it implies the existence of an earlier and still-undefined period of technological experimentation in the Central American isthmus.

La correlación de rasgos arqueológicos con secuencias estratigráficas de tefras y fechamientos radiocarbónicos en la cordillera volcánica del noroeste de Costa Rica ha proporcionado evidencia de un complejo cerámico Formativo Temprano a Medio con fechas de hasta 2000 A.C. Se ha hallado cerámica de la fase Tronadora en asociación con evidencias de patrones hortícolas y sedentarios tempranos. Se han llevado a cabo comparaciones estilísticas con otra cerámica temprana proveniente de Centroamérica, hecho que ha ayudado al mejoramiento de la cronología de las sociedades sedentarias en Costa Rica y Nicaragua. Las diferencias entre la cerámica Tronadora y los complejos más tempranos de Mesoamérica y del sur de Centroamérica indican un alto grado de regionalización en estilos cerámicos durante el período Formativo Temprano. Sin embargo, las semejanzas también indican la participación común del noroeste de Costa Rica y el sur de Mesoamérica en amplias redes de interacción durante esta época. La cerámica Tronadora no representa una tecnología incipiente ni las consecuencias de una difusión de producción cerâmica desde Mesoamérica o el noroeste de Sudamérica. En cambio, implica la existencia de un período más temprano y aún no bien definido de experimentación tecnológica en el istmo centroamericano.

Archaeology in northwestern Costa Rica has provided new information on the earliest ceramic-producing cultures of southern Central America. Tronadora pottery, present at sites on Lake Arenal ca. 2000 B.C., is the earliest dated ceramic complex between central Panama and Pacific Guatemala. It has been found in association with simple structures and maize. The Tronadora phase provides a time depth for sedentary Early Formative cultures in northwestern Costa Rica comparable to the earliest ceramic-producing societies in Mesoamerica and the central Andes (although not as early as those in Brazil, Colombia, Ecuador, and Panama), and opens new avenues for the investigation of interregional contacts and the nature of in situ cultural development in southern Central America.

The nature of early villages in Costa Rica remains poorly understood, but information on the chronology of cultural development is growing rapidly. The first stratigraphic excavations, undertaken by Coe and Baudez in the late 1950s, succeeded in defining a Late Formative occupation beginning about 300 B.C. (uncalibrated) that they called the "Zoned Bichrome" period (Baudez and Coe 1962; Coe and Baudez 1961). Haberland was the first to discover Early Formative ceramics in levels beneath Zoned Bichrome material during excavations at Los Angeles on Ometepe Island in neighboring Nicaragua in 1962. He suggested a date for Dinarte ceramics of 1300 B.C. (uncalibrated)

JOHN W. HOOPES • Department of Anthropology, University of Kansas, Lawrence, KS 66045

Latin American Antiquity, 5(1), 1994, pp. 3–30.

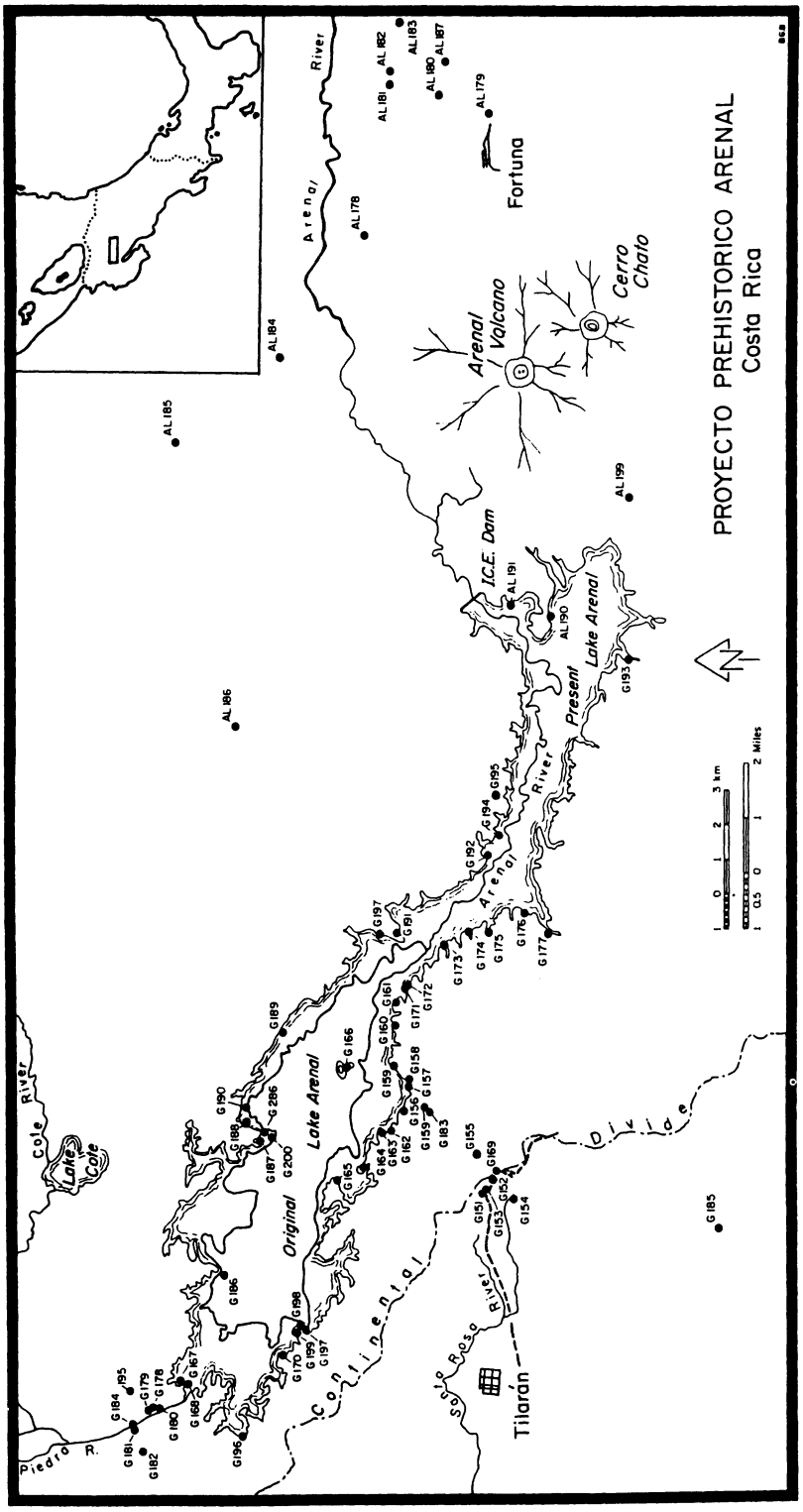

Figure 1. Map of Lake Arenal indicating Proyecto Prehistórico Arenal sites and volcanoes.

on stylistic grounds (Haberland 1966, 1978, 1986, 1992). It was not until the 1970s that other early ceramics were identified at sites in Costa Rica. Snarskis (1978) described early complexes from the sites of La Montaña, near Turrialba, and Chaparrón, near San Carlos, and Lange (1980) reported early Loma B ceramics from deep excavations at Vidor, on the Bay of Culebras. Since then, archaeologists have identified early pottery at a variety of sites in the Atlantic watershed and central highlands (Snarskis 1984:206), the northwestern cordillera (Hoopes 1984, 1985, 1987; Norr 1986), central Guanacaste (Odio 1991), and southern Costa Rica (Corrales 1985, 1989). A pattern is beginning to emerge that suggests that sedentary horticulturists settled most of the region by at least 1000 B.C., and in some places as early as 2000 B.C.

For many years, archaeologists (e.g., Healy 1980; Snarskis 1978, 1981) felt that external influences from either Mesoamerica or South America on local populations played a significant role in the introduction of agriculture and its concurrent effects on sedentism in Costa Rica. Linguistic patterns, ethnohistoric accounts, and the material culture of recent prehistory confirm important relationships between societies of ancient Costa Rica and their neighbors to the north and south. Whereas there are strong cases for migrations from Mesoamerica to Costa Rica in the Classic and Postclassic periods (Chapman 1960; Fowler 1989; Hoopes and McCafferty 1989), however, arguments for earlier, post-Paleoindian migrations are difficult to sustain. The fact that genetic markers and linguistic data argue against significant migrations from South America (Barrantes et al. 1990) emphasizes the importance of models for in situ culture change.

Questions of culture history remain at the forefront of Costa Rican archaeology (Fonseca Z. 1992). The chief methodology is comparative, and seeks to understand the relationships between local assemblages and larger cultural-historical frameworks (see Lange and Stone 1984). This approach is justified by still limited knowledge of the prehistory of this region, especially as compared to Mesoamerica and the central Andes. We must understand temporal and geographical relationships in detail if we are to address questions about culture change, process, symbolism, and adaptation. This paper focuses on a description of Tronadora-phase ceramics with special reference to chronology, links with related complexes, and the interpretation of cultural evolution in southern Central America.

THE PROYECTO PREHISTORICO ARENAL

The Proyecto Prehistórico Arenal (Sheets and McKee 1994; Sheets and Mueller 1984; Sheets et al. 1991), initiated in 1984, has been a multidisciplinary effort to use the unique depositional environment created by volcanoes in northwestern Costa Rica to recover information on prehistoric settlement and subsistence patterns. The study area was chosen because substantial tephra horizons in direct association with prehistoric occupations provided an ideal context for studying the effects of volcanic activity on human populations through time.

The Arenal Valley is located along the eastern boundary of the province of Guanacaste in northwestern Costa Rica (Figure 1). The environment is tropical, much of it classified by Holdridge as Tropical Moist Forest, characterized by tall, semideciduous evergreen forests, usually with abundant palms (Hartshorn 1983:121). Annual rainfall at Tronadora is about 2,600 mm, and the dry season is short, averaging about three months (February–April). Mean annual temperature is 23.6°C (Tosi 1980:27).

The valley is now occupied by an artificial lake—the modern enlargement of an ancient lake—immediately west of Arenal and Chato volcanoes. The region has been geologically very active in recent times, although Arenal was largely unnoticed by volcanologists until violent eruptions occurred in 1968 (Melson 1994; Melson and Saenz 1968). Before the existence of the volcanoes, a paleovalley was drained by the eastward-flowing Arenal paleoriver. The Chato volcano formed before Arenal on the southern flank of the paleovalley and displaced the paleoriver's drainage northward. Around 1000 B.C., the Arenal volcano erupted near the base of Chato's cone, and deposited pyroclastic and lava flows to the northeast that dammed the drainage, which resulted in the formation of the original Lake Arenal and shifting of the Río Arenal drainage northward (Borgia

Years A.D./B.C	Cordillera Phases	Greater Nicoya Periods	Atlantic Watershed Periods	Greater Chiriqui Periods/Phases	LCA	Years B.P.
1500		Late				450
1400	Tilarán	Polychrome				550
1300			Late	Chiriquí B	VI	650
1200						750
1100		Middle				850
1000	Silencio	Polychrome				950
900						1050
800			Transitional	Chiriquí A		1150
700		Early			V	1250
600		Polychrome				1350
500						1450
400	Late	Late Zoned Bichrome		Aguas		1550
300	Arenal			Buenas		1650
200						1750
100		Middle				1850
0		Zoned Bichrome	Zoned Bichrome			1950
100				Quebradas		2050
200	Early				IV	2150
300	Arenal					2250
400						2350
500						2450
600		Early				2550
700	Late	Zoned Bichrome				2650
800	Tronadora					2750
900				Curré		2850
1000						2950
1100						3050
1200			Early/Middle			3150
1300			Formative			3250
1400	Early	Early				3350
1500	Tronadora	Formative				3450
1600						3550
1700						3650
1800						3750
1900						3850
2000		??????????????????????	??????????????????????	Boquete		3950
2100				(Archaic)	III	4050
2200						4150
2300						4250
2400						4350
2500						4450
2600						4550
2700						4650
2800						4750
2900						4850
3000	Fortuna					4950
3100	(Archaic)					5050
3200				Talamanca		5150
3300				(Archaic)		5250
3400						5350
3500						5450
3600						5550
3700						5650
3800						5750
3900						5850
4000						5950

Figure 2. Chronological chart of archaeological periods and phases in Costa Rica.

et al. 1988:87–88). An earth-fill dam constructed in 1978 caused further flooding of the valley by expanding Lake Arenal.

The last active period of the Chato volcano is dated to about 4,000 years ago (Borgia et al. 1988: 97), at a time when ceramic-producing sedentary societies were present in the Arenal Basin. The

Arenal volcano is between 3,000 and 4,000 years old and has had at least 10 major eruptions. Tephra deposited by the two volcanoes provides the opportunity to correlate buried strata with cultural assemblages from sites within the area affected by volcanic ashfall. Catastrophic eruptions were on such a scale that it was possible to address hypotheses regarding effects of natural disasters on human settlement, agriculture, and land-use patterns. Furthermore, while one can see the size and extent of Chato and Arenal's prehistoric eruptions in geological profiles and petrographic studies, the chronology of these events is largely dependent upon the interpretation of associated archaeological materials.

Limited exploration of the Arenal Valley was undertaken prior to the creation of the modern lake (Aguilar P. 1984), which undoubtedly submerged many prehistoric sites. Apart from Aguilar P.'s study, which describes several Zoned Bichrome sites, the only archaeological research in the region had consisted of observations of looted cemeteries east of the volcano by Stone and Balser (1965). The investigations by the Proyecto Prehistórico Arenal concentrated on sites around the perimeter of the existing lake and on neighboring properties. Results of fieldwork have been reported in a number of contexts (Hoopes 1987, 1991; Mueller 1982, 1986; Sheets and McKee 1994; Sheets and Mueller 1984; Sheets and Sever 1988; Sheets et al. 1991).

We have defined six phases for the Arenal region (Figure 2). Formulation of the temporal framework depended especially on a collection of 12,629 diagnostic sherds that provides information on vessel form or decoration, extracted from 431 ceramic lots that represent surface collections, stratified deposits, and features at 43 sites. Absolute chronology is based on a series of 30 ^{14}C dates and comparisons with other dated materials (see Hoopes [1984, 1987, 1994] and Sheets and McKee [1994] for further discussion).

The Early (2000–1000 B.C.) and Late (1000–500 B.C.) Tronadora phases represent the period of occupation by the earliest ceramic-producing cultures in the region. They are characterized by the Tronadora ceramic complex, which is described below. Tronadora pottery is closely related to other early ceramic complexes of Costa Rica and shares a number of important modes with early pottery from Guatemala, Nicaragua, and Panama.

TRONADORA VIEJA

Tronadora pottery is rare. Tronadora-phase sherds were identified at 20 of the 43 sites sampled during the 1984 and 1985 seasons, but quantities were low; only four sites yielded 15 or more Tronadora sherds. Tronadora Vieja (G-163), a multicomponent site first recorded in 1984, is the most important for interpreting this phase. It is situated on the south shore of Lake Arenal (Figure 3), on a gentle, north-facing slope 545 m asl. In prehistoric times the site overlooked the point at which the Río Tronadora entered a broad, swampy basin near the headwaters of the Arenal paleoriver. Low hills of the Continental Divide rise immediately to the south, but the site would have provided an ideal vantage from which the region's prehistoric occupants could have observed birds and other game, as well as the movements of humans, in the Arenal Valley. The Arenal and Chato volcanoes dominate the horizon to the east. The site is estimated to have an area of approximately 100 x 60 m (.6 ha), but modern disturbance and heavy erosion make it difficult to say how much of the original site remains.

The area in which the site is located has been heavily utilized for grazing and agriculture in historic times, but it was probably covered with dense rain forests in the distant past. Pollen and phytolith profiles indicate palms, vines (Malphigiaceae), and saprophitic plants (Piperno 1994). Pine (*Pinus* sp.) pollen was also present, but this species is not native to Costa Rica, and pollen may have been transported by wind from regions such as eastern Nicaragua (Clary 1994). Modern Lake Arenal encroaches on the site, whereas in prehistoric times it would have been a large, marshy lake less than a kilometer to the north, and a rich source of fish, birds, and other game.

Methods

Excavations at Tronadora Vieja in 1984 and 1985 (Bradley 1994; Bradley et al. 1984; Sheets et al. 1991) probed 140 m^2, about 5 percent of the total area. The choice of locations for excavations was made on the basis of testing with a posthole digger. Spot testing for inorganic phosphates (Eidt

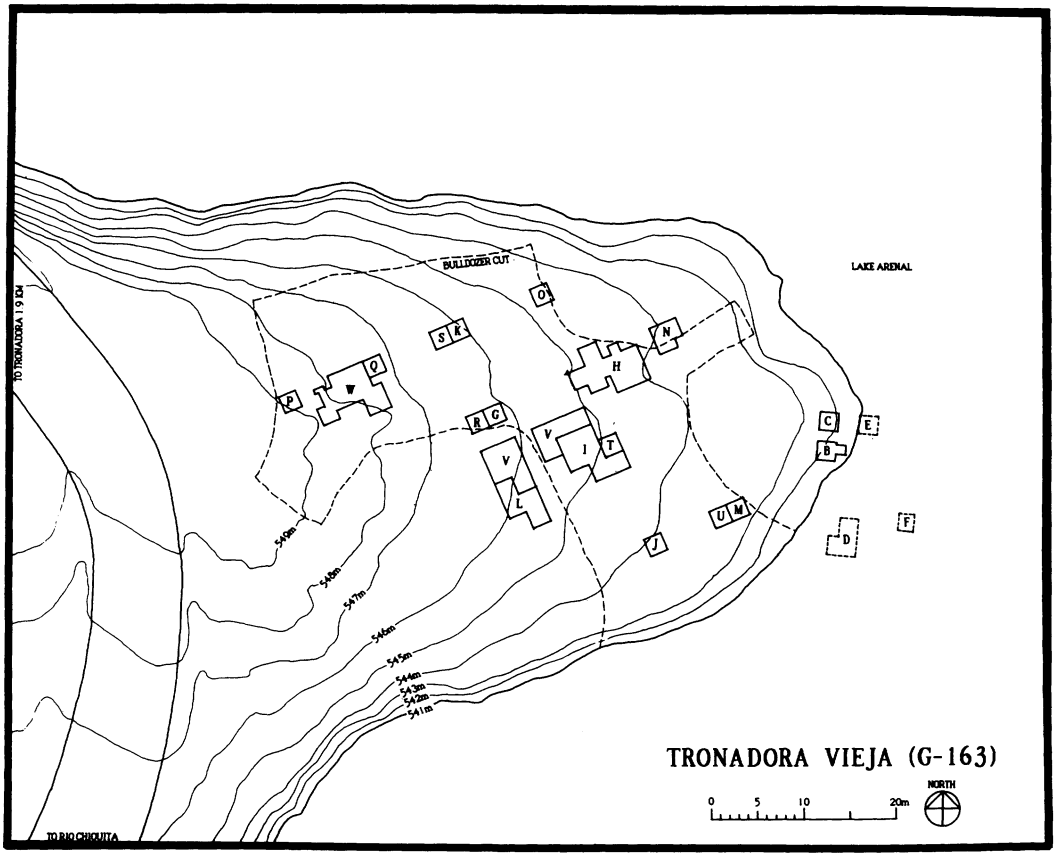

Figure 3. Map of Tronadora Vieja (G-163).

1984) showed higher concentrations at depths of more than 90 cm below the surface, and the paucity of cultural remains in the upper strata of the site was confirmed by subsequent excavations. A bulldozer was used to strip off culturally sterile upper strata to assist with the exposure of horizontal features.

The regional tephra sequence (Melson 1984; Mueller 1984) evident in excavation units at the site (Figure 4) made it possible to excavate by natural stratigraphy in all excavations; artificial levels were used only where natural strata were thicker than 10 cm. Attempts at both dry and wet screening were frustrated by the high clay content of the soil, and artifact recovery relied upon careful shovel- and trowel scraping.

Volcanic Stratigraphy

Interpretation of stratigraphy was assisted by the definition of a regional stratigraphic sequence based on airfall tephras deposited by the Chato and Arenal volcanoes. Tephra from most eruptions was blown by prevailing winds and deposited in a broad apron southwest of the volcano, each unit "a basal coarse tephra layer deposit on soil and overlain by fine tephra, which in prehistoric units becomes yet another soil zone" (Melson 1984:39). These units were especially clear in a 20-m-thick profile at El Tajo, situated on the south side of a hill 7 km downwind of the volcano. This was used to define the "El Tajo Sequence," a reconstruction of the eruptive history of the volcano (Aguilar 1984; Melson 1982, 1984; Melson and Saenz 1973). Nine successive units have been identified,

Figure 4. Stratigraphic profile from Op. L, Tronadora Vieja, illustrating volcanic tephras and associated paleosols. The light stratum in the upper half of the profile is Unit 40/41, representing a major eruption of Arenal ca. A.D. 800. The dark band in the center is Unit 50. Cultural material at the site came from between this stratum and Unit 65 (at the base of excavations). Photo by John Hoopes.

each representing a major explosive event or series of small explosions. The El Tajo Sequence was in turn correlated with stratigraphy recognized in excavations at a number of sites (Mueller 1984).

A one-to-one correspondence between El Tajo tephra units and archaeological strata was not always possible to establish owing to compressed stratigraphy and the effects of natural and cultural disturbance at archaeological sites. Tephra was not preserved in uniform layers, as a result of local erosional patterns and disturbance by bioturbation and cultural activity. For this reason a second sequence, named the "Silencio Sequence," was formulated to describe archaeological strata. The following is a description of strata that correspond to the earliest human activities in the region:

Unit 65. At the base of deposits is a paleosol known as uPPv or the Aguacate Formation (Borgia et al. 1988). It is a heavily weathered, red to orange, clay-rich substrate derived from volcanic deposits that predate both the Chato and Arenal volcanoes. It appeared at the base of all excavations (about 150–180 cm below the modern ground surface at Tronadora Vieja) and is visible along the eroded shore of Lake Arenal. This substrate was sterile except at Tronadora Vieja, where it was penetrated by prehistoric excavations and contained cultural material to a depth of 10 cm.

Unit 65 refers to the top of uPPv, which excavation penetrated to 10 cm. It appears as a layer of the orange substrate mixed with fragments of darker overlying deposits. The oldest known artifact from Unit 65 is a Turrialba-style fluted Paleoindian projectile point that may date as early as 8000 B.C. (Sheets et al. 1991). Six ^{14}C dates associated with Archaic-style lithic debitage from Unit 65 range between 3700 and 2800 B.C. (Table 1). Archaeological materials from Unit 65 represent human activity that occurred on a thin tropical soil or the surface of uPPv.

Unit 64. Unit 64 is a shallow, dark, clay-laden stratum on the surface of Unit 65, identified only at Tronadora Vieja. Initially believed to represent a thin soil of indefinite origin that predated tephras from the Arenal volcano, it may derive in part from tephra expelled by the Chato volcano's first eruptions. Where strata are undisturbed, Unit 64 appears between Unit 65 and Unit 61. Where Unit 61 is absent, Unit 64 is found between Units 65 and 60. The highly discontinuous nature of Unit 64 at Tronadora Vieja indicates that Unit 65 was frequently exposed to later cultural activity.

Table 1. List of Radiocarbon Ages for Samples from Sites in Costa Rica.

Site	Provenience	Lab Number	Radiocarbon Age[a] (years B.P.)	Calibrated Age[b]	Reference
Piedras del Sol	Unit 65	Tx-5286	4,890 ± 100	3940–3380 cal B.C.	Hoopes 1987:586
Tronadora Vieja	Unit 65	Tx-5275	4,600 ± 70	3610–3050 cal B.C.	Hoopes 1987:576
Tronadora Vieja	Unit 65	Tx-5278	4,580 ± 80	3610–3040 cal B.C.	Hoopes 1987:582
Tronadora Vieja	Unit 64	Tx-5276	4,450 ± 70	3350–2910 cal B.C.	Hoopes 1987:578
Tronadora Vieja	Unit 65	Tx-5274	4,210 ± 70	2920–2580 cal B.C.	Hoopes 1987:575
Tronadora Vieja	Unit 65	Tx-5277	3,730 ± 100	2460–1790 cal B.C.	Hoopes 1987:580
Tronadora Vieja	Unit 65	SI-?	3,675 ± 100	2390–1750 cal B.C.	Melson et al. 1986
La Espina	southeast flank	unspecified	3,510 ± 120	2140–1520 cal B.C.	Borgia et al. 1988:97
Méndez	TR-4, N6W1	UCLA-2167A	3,500 ± 60	1970–1680 cal B.C.	Norr 1986:140
between Chato and Chatito	north of saddle	unspecified	3,500 ± 50	1940–1680 cal B.C.	Borgia et al. 1988:97
Tronadora Vieja	Units 61/64	Tx-5279	3,480 ± 320	2850–990 cal B.C.	Hoopes 1987:583
Mogote	hearth	Beta-30986	3,470 ± 50	1900–1670 cal B.C.	Hurtado de Mendoza and Alvarado Induni 1988:82
La Montaña	Layer D	UCLA-2113A	3,465 ± 160	2200–1410 cal B.C.	Snarskis 1978:106
Cerro Chato	west–northwest base	unspecified	3,460 ± 70	1940–1540 cal B.C.	Borgia et al. 1988:97
Mogote	hearth	Beta-30985	3,410 ± 60	1880–1520 cal B.C.	Hurtado de Mendoza and Alvarado Induni 1988:82
Mogote	hearth	GX-12885	3,400 ± 90	1920–1460 cal B.C.	Hurtado de Mendoza and Alvarado Induni 1988:82
east of Sangregado Dam	road cut	unspecified	3,025 ± 150[c]	1610–840 cal B.C.	Borgia et al. 1988:97
La Fábrica	?	UCLA-2167F	2,910 ± 100	1400–830 cal B.C.	Lange and Stone 1984:385
Quebrada Guillermina	below ET9	unspecified	2,895 ± 145[d]	1430–800 cal B.C.	Borgia et al. 1988:97
Vidor	Feature 13	UCLA-2177A	2,830 ± 80	1250–810 cal B.C.	Lange 1980:35
Quebrada La Palma	road cut	unspecified	2,650 ± 115[e]	1020–410 cal B.C.	Borgia et al. 1988:97
La Montaña	Layer D	UCLA-2113D	2,500 ± 60	800–400 cal B.C.	Snarskis 1978:106
La Montaña	Layer D	UCLA-2113N	2,500 ± 60	800–400 cal B.C.	Snarskis 1978:106
Tronadora Vieja	Unit 54?	Tx-5280	2,470 ± 560	1930–670 cal B.C.	Hoopes 1987:585
Bolívar	Unit 65	Tx-5271	2,340 ± 170	820 cal B.C.–cal A.D. 10	Hoopes 1987:569
La Montaña	Layer D	UCLA-2113B	2,275 ± 160	800 cal B.C.–cal A.D. 60	Snarskis 1978:106
Méndez	Lot 129	UCLA-2163	2,250 ± 60	400–160 cal B.C.	Norr 1986:140
La Montaña	Layer D	UCLA-2113M	2,230 ± 60	400–110 cal B.C.	Snarskis 1978:106
Vidor	Level 3	UCLA-2177B	2,200 ± 60	390–60 cal B.C.	Lange 1980:35
Ortega	Level 6	GsY[Gif]-100	2,194 ± 70[f]	400–40 cal B.C.	Baudez 1967:27
El Tajo	Unit 8 (top)	SI-3459	2,170 ± 65	390–40 cal B.C.	Aguilar P. 1984:74

Table 1. Continued.

Site	Provenience	Lab Number	Radiocarbon Age[a] (years B.P.)	Calibrated Age[b]	Reference
Tronadora Vieja	Unit 60	Tx-5081	2,030 ± 300	800 cal B.C.–cal A.D. 640	Hoopes 1987:562
El Tajo	Unit 8 (top)	I-10804	1,830 ± 80	cal A.D. 20–410	Aguilar P. 1984:74
Ortega	Level 6	Y-850	1,700 ± 70	cal A.D. 210–540	Baudez 1967:27
Viboriana	Unit 50	Tx-5082	1,530 ± 130	cal A.D. 240–770	Hoopes 1987:563

[a] Dates in "years B.P." represent uncorrected radiocarbon years before A.D. 1950. They are based on a 5,568-year half-life for ^{14}C and are presented with ±1-sigma error ranges. Unless otherwise noted, all dates were obtained from samples of charcoal. There is no published documentation that any dates in this table other than those from the University of Texas laboratory have been corrected for ^{13}C fractionation.

[b] These represent calibrated 2-sigma, 95% confidence intervals as calculated using CALIB 3.03 (Stuiver and Reimer 1993a, 1993b). Calibrations are based on dendro-corrected, bidecadal curves (Pearson and Stuiver 1993; Stuiver and Pearson 1993). Dates have been rounded to the nearest decade as recommended in the *CALIB User's Guide Rev 3.03* (Stuiver and Reimer 1993b).

[c] Date on organic particles from buried paleosol.

[d] Date on organic particles from buried paleosol.

[e] Date on organic particles from buried paleosol.

[f] Weighted average of two assays on the same sample. A third assay on this sample is Y-850. These three assays were calculated prior to 1977, when the term "conventional radiocarbon age" was accepted to imply ^{13}C normalization to the base of $\delta^{13}C_{PDB} = 25‰$ (Stuiver and Polach 1977). They have been corrected for this normalization with an estimated uncertainty of 2.5 per mil in $\delta^{13}C$ (Stuiver and Reimer 1993b:4).

Ceramics also indicate that Unit 64 was often disturbed. "Unit 62" is a mix of Aguacate and overlying layers that represents disturbance that could have happened at any time and hence has no chronological significance.

Units 61 and 60. Unit 61, the earliest clearly defined tephra deposit, is a compact layer of fine-grained, sandy, dark gray tephra that overlies Unit 64 and exposed portions of Unit 65 at depths of 150–170 cm below the modern ground surface at Tronadora Vieja. The origins of this tephra are still unclear, although there are two likely explanations. One is that it was deposited by the the last major eruption of the Chato volcano ca. 1800 B.C.; the other is that it was deposited by the initial eruption of the Arenal volcano ca. 900 B.C.

The identification of Unit 61 is assisted by ^{14}C dates. Two samples from carbonized branches and one from carbonized organic matter embedded in tephra near the volcano from the youngest eruption of Chato yielded dates of 2140–1520 cal B.C. [unspecified lab number: 3510 ± 120 B.P.], 1940–1680 cal B.C. [unspecified lab number: 3500 ± 50 B.P.], and 1940–1540 cal B.C. [unspecified lab number: 3460 ± 70 B.P.] (Borgia et al. 1988:97; see Table 1). Overlapping from 1940 to 1680 cal B.C. in the 95 percent confidence interval, they indicate a date of ca. 1800 cal B.C. for Chato's last explosive activity. At Tronadora Vieja, the earliest date for the emplacement of Unit 61 is indicated by two ^{14}C assays: 2460–1790 cal B.C. [Tx-5277: 3730 ± 100 B.P.], from the upper surface of Unit 65, and 2850–990 cal B.C. [Tx-5279: 3480 ± 320 B.P.]. Both are on charcoal associated with cultural remains from beneath Unit 61. A fifth date of 2390–1750 cal B.C. [SI-?: 3675 ± 50 B.P.] obtained from charcoal near the top of the uPPv paleosol at Tronadora Vieja (Melson et al. 1986) is also suggested as corresponding to Chato's last activity (Borgia et al. 1988:97).

Three dates from samples of the basal Arenal paleosol at locations east of Lake Arenal are: 1610–840 cal B.C. [unspecified lab number: 3025 ± 150 B.P.], 1430–800 cal B.C. [unspecified lab number: 2895 ± 145 B.P.], and 1020–410 cal B.C. [unspecified lab number: 2650 ± 115 B.P.] (Borgia et al. 1988:97). They overlap from 1020 to 840 cal B.C. at the 95 percent confidence interval, and provide an estimated date for Arenal's first volcanic activity at 900 B.C. (Borgia et al. 1988:98). Another date of 800 cal B.C.–cal A.D. 640 [Tx-5081: 2030 B.P. ± 300] was obtained from an aggregation of small fragments of charcoal from two excavation units. Associated with Tronadora-phase ceramics, it was reported as having come from Unit 60 and below, but its utility is limited by its poor provenience and large 2-sigma range. Until further data are available the possibility cannot be ruled out that Unit 61 may correspond to the first eruption of Arenal rather than the last eruption of Chato.

At present, the most parsimonious interpretation is that Unit 61 is tephra from the last explosion of Chato ca. 1800 B.C. (This interpretation differs from that presented in Sheets et al. [1991:448], where Arenal is identified as the source of Unit 61.) There is a close correspondence in dates on charcoal embedded in tephra near the volcano and samples immediately below Unit 61 at Tronadora Vieja. Chato's last eruption was a powerful one, destroying much of the existing volcanic cone. It is unlikely that this explosion would not have left a significant deposit of tephra on top of Unit 65, even at Tronadora Vieja. The archaeological data also support a close correspondence between Chato's eruption and human activity at the site. The association between ^{14}C dates of ca. 1800 B.C. and Tronadora-phase features and artifacts is clear. Furthermore, there is evidence for two structures, one immediately below and the other directly on the surface of the Unit 61 tephra, both with similar ceramic assemblages (see below). If Unit 61 derives from Arenal tephra deposited ca. 900 B.C., it is necessary either to: (1) deny the associations of dates Tx-5277 and Tx-5279 with Tronadora-phase ceramics and occupational features, or (2) accept the reoccupation of the same portion of the site by people with an identical material culture after a 900-year hiatus.

Unit 60 is a black stratum that overlies Unit 61. At Tronadora Vieja, it appears at depths of 130–140 cm and varies in thickness from 10 to 20 cm. It is rich in cultural content, which includes pottery, stone tools, and archaeological features. The origins of this stratum are also unclear. It may represent a paleosol developed from Unit 61, the soil formed from and on top of this unit. Alternatively, it may represent weathered tephra from the initial eruption of Arenal. Scoria characteristic of ET9 (El Tajo 9), the basal tephra of Arenal, was identified in Unit 60. This suggests that Unit 60, which overlies Unit 61, may correspond to Arenal's first eruption. However, Unit 61 is not highly weathered, as one would expect it to be if it had been deposited by Chato ca. 1800 B.C. and

was not buried by tephra from Arenal for 900 years. Unit 60 is, furthermore, a well-developed paleosol whereas the paleosol below ET8 is weakly developed (Borgia et al. 1988:97). Because 900 years would have been sufficient for the development of a thick paleosol from weathered tephra, it is more likely that Unit 60 represents a paleosol—possibly corresponding to ET10—that developed on Unit 61 and was in turn buried by the first tephras from Arenal ca. 900 B.C. The archaeological data also argue against a wide separation in time between the emplacement of Unit 61 and the formation of Unit 60. If Units 61 and 60 represent tephras deposited 900 years apart, one would expect recognizable differences between the ceramic assemblages from Units 61 and 60, but the two contained virtually identical assemblages of Tronadora-phase ceramics, interpreted as evidence of an occupation dating somewhere between 2000 and 1000 B.C.

Unit 55. Unit 60 is overlain by Unit 55, a coarse, yellow tephra layer. There is not yet a consensus regarding the identification and dating of this stratum, which may correspond either to ET9, the earliest Arenal tephra, or to ET8 in the El Tajo profile (Melson 1984:47). This problem could be resolved through chemical analysis; ET9 is a dacitic tephra, whereas ET8 is basaltic (Melson 1982). As noted above, Borgia et al. (1988:98) date Arenal's earliest activity to 900 B.C. Sheets et al. (1991: 448), however, favor a date of 800 B.C. for Unit 55, and identify it with Arenal's *second* major eruption; they date the first eruption at 1800 B.C., which is suggested by Borgia et al. as the date of an eruption from *Chato*. If Unit 61 represents tephra deposited by Chato, and Unit 60 is a paleosol that formed on top of it, then Unit 55 corresponds to the earliest Arenal tephra, with a date of ca. 900 B.C.

Upper Strata. Overlying Unit 55 are the "Upper 50s" strata, recognized at sites elsewhere in the Arenal Basin. Together they appear as a broad, light brown horizon, 40–50 cm thick in all profiles. These strata yielded a large quantity of material representing Arenal-phase activity. Unit 54, overlying Unit 55, probably corresponds with ET8, Arenal's second major eruption. The uppermost part of ET8 is dated by two samples of charcoal from prehistoric hearths with Arenal-phase ceramics: 390–40 cal B.C. [SI-3459: 2170 ± 65 B.P.] and cal A.D. 20–410 [I-10804: 1830 ± 80 B.P.] (Aguilar P. 1984). It is curious that although the two dates bracket the first decades B.C., they do not overlap even at the 95 percent confidence interval. When calibrated with a decadal, high-precision curve (Stuiver and Becker 1986), however, the dates *do* overlap in the interval from 90 to 40 cal B.C. Given an estimated time of 300–500 years for soil development between the deposition of ET8 and the dated charcoal (see Hoopes 1987:714), we can date the deposition of ET8 to ca. 550–350 B.C.

The date for ET8 raises some additional problems. If the deposition of ET9 occurred ca. 900 B.C. and the deposition of ET8 at 350 B.C., there should have been sufficient time (550 years) for the development of a thick paleosol between the two. Melson (1984:48) notes, however, that the soil zone on ET9 is *less* well developed than that on ET8. It is likely that there is something wrong with Melson's assumption of the equivalency of rates of soil development on tephras. Until we know more about this process, it is probably best to treat estimates based on this assumption with caution. To date, there are no radiocarbon samples directly associated with either the base of ET8 or with Unit 55, and the time of the deposition of this stratum—although probably sometime between 900 and 350 B.C.—remains far from certain.

Correlations of the other "Upper 50s" units El Tajo strata remain unclear. Unit 53 is associated with either ET7 or ET6, or both. Unit 52 correlates petrologically with ET5 (Melson 1984:47). An occupation associated with these strata at Sitio Bolívar (G-164) dates to A.D. 300–600 (Hoopes and Chenault 1994). Unit 50, which overlies the "Upper 50s" is a black zone, 20 cm thick and visible in all profiles. At Viboriana (G-175) charcoal from Unit 50 provided a date of A.D. 240–770 [Tx-5082: 1530 ± 130 B.P.]. Unit 50 was sterile at Tronadora Vieja, and it provides a convenient upper boundary for cultural deposits. Other, later stratigraphic units and their archaeological correlations from other sites in the region are described by Hoopes (1987).

Reconstruction of Past Activity at Tronadora Vieja

Survey, test pitting, and excavation at Tronadora Vieja revealed three principal components: the Fortuna phase (ca. 4000–2000 B.C.), the second half of which may overlap with an early ceramic

occupation (what happened during this period is not understood for lack of good stratigraphic separation in pre-2000 B.C. levels); the Tronadora phase (2000–500 B.C.); and the Early Arenal phase (500 cal B.C.–A.D. 1). A small Late Arenal phase (A.D. 1–600) and very small Tilarán phase (A.D. 1300–1500) component are also present, the latter restricted to near-surface strata. The three early phases are represented primarily by domestic activities, with very limited evidence for specialized manufacturing, agricultural, ceremonial, and funerary activities.

Fortuna-Phase Features and Assemblages. A fluted Paleoindian point of locally available chert, from Unit 65 at nearby Sitio Bolívar (G-164), indicates that the Arenal Valley was occupied by big-game hunters as early as 10,000 B.P. (Sheets 1994). At Tronadora Vieja and other sites there was evidence for an Archaic-period occupation, labeled the Fortuna phase, in the form of chipped lithic debitage in association with concentrations of wood charcoal at the very base of cultural deposits (Sheets 1994).

The earliest date for the Fortuna phase is 3940–3380 cal B.C. [Tx-5286: 4890 ± 100 B.P.], from the preceramic site of Piedras del Sol (AL-186). This phase is represented at Tronadora Vieja by Archaic-style chalcedony percussion flakes from Unit 65, found in association with five ^{14}C dates that range from 3610–3050 cal B.C. [Tx-5275: 4600 ± 70 B.P.] to 2390–1750 cal B.C. [SI-?: 3675 ± 100 B.P.] (Table 1). All but Tx-5276 come from a concentration that appeared to be the remains of a single fire.

There are several inconsistencies with regard to the foregoing dates. Although Tx-5275, Tx-5278, Tx-5274, and SI-? all derive from the same concentration of wood charcoal, only Tx-5275 and Tx-5278 overlap each other at the calibrated 2-sigma range. It is likely that the discrepancies result from varying ages in the wood that was burned to form the sample; charcoal from wood in a primary forest with ancient trees would probably be especially prone to this type of dating problem. If the three samples in fact represent Archaic-period activity, this could also explain the discrepancy. The last, and youngest, date (SI-?) was, however, run on a portion of the same sample of charcoal as Tx-5274. These two dates do not overlap either, although the 2-sigma ranges do approach each other at ca. 2500 B.C. Laboratory error is also a possibility, but neither of the radiocarbon labs which dated this sample has been able to explain the discrepancy.

Tx-5276 is especially problematic. It was associated with both Archaic-style flakes and Tronadora pottery, stratigraphically situated between a discontinuous patch of Unit 61 and Unit 60. It is believed to be too early for the ceramics on stylistic grounds, but its association with a burned maize kernel and Tronadora pottery with charcoal residue argues that it does not pertain to the Fortuna phase. Tx-5277, at 2460–1790 cal B.C., was also associated with both Archaic-style flaked debitage (Sheets 1994) and Tronadora pottery with charcoal residue. Although the stratigraphic separation of Fortuna- and Tronadora-phase materials is poor, their temporal division is estimated at about 2000 B.C. Despite the lack of chronological clarity for this transition, it is apparent that the cultural sequence in the Arenal region differs from central Panama, where pressure-flaked projectile points disappear ca. 5000 B.C. (Cooke 1984:268). This leaves open the possibility that the flaked lithics from Tronadora Vieja are not restricted to the Fortuna phase, and that Tronadora pottery *may* date to before 2000 B.C.

Tronadora-Phase Features and Assemblages. Artifacts and domestic features in Units 65, 64, 61, and 60 at Tronadora Vieja indicate a small Tronadora-phase settlement. Postholes, fire-cracked rock, lithic debitage, sherds from utilitarian vessels, charred macrobotanical remains, and charcoal appeared throughout these earliest strata in all excavations. Tronadora-phase activity began on the surface of Aguacate (Unit 65) and continued through at least one major volcanic eruption. The following discussion summarizes the stratigraphic evidence, in its order of deposition.

Unit 64. The most abundant occupational features were found beneath Unit 61, in Units 64 and 65. Among these was a Tronadora-phase dwelling at the interface of Units 61 and 64 (Figure 5). It was delineated by seven postholes, each containing Unit 61 tephra. A single sample of charcoal from the floor of the structure dates to 2850–990 cal B.C. [Tx-5279]. Concentrations of fire-cracked rock, sherds with charcoal residue, a mano fragment, a small metate support, a flake and core of white chalcedony, and a bifacial tool fragment were associated with this feature. Pollen grains from the chenopod-amaranth family were found in one of the postholes (Clary 1994). Associated ceramics consist of 70 sherds, including types Tonjibe Beige and Tigra Grooved-Punctate (see below).

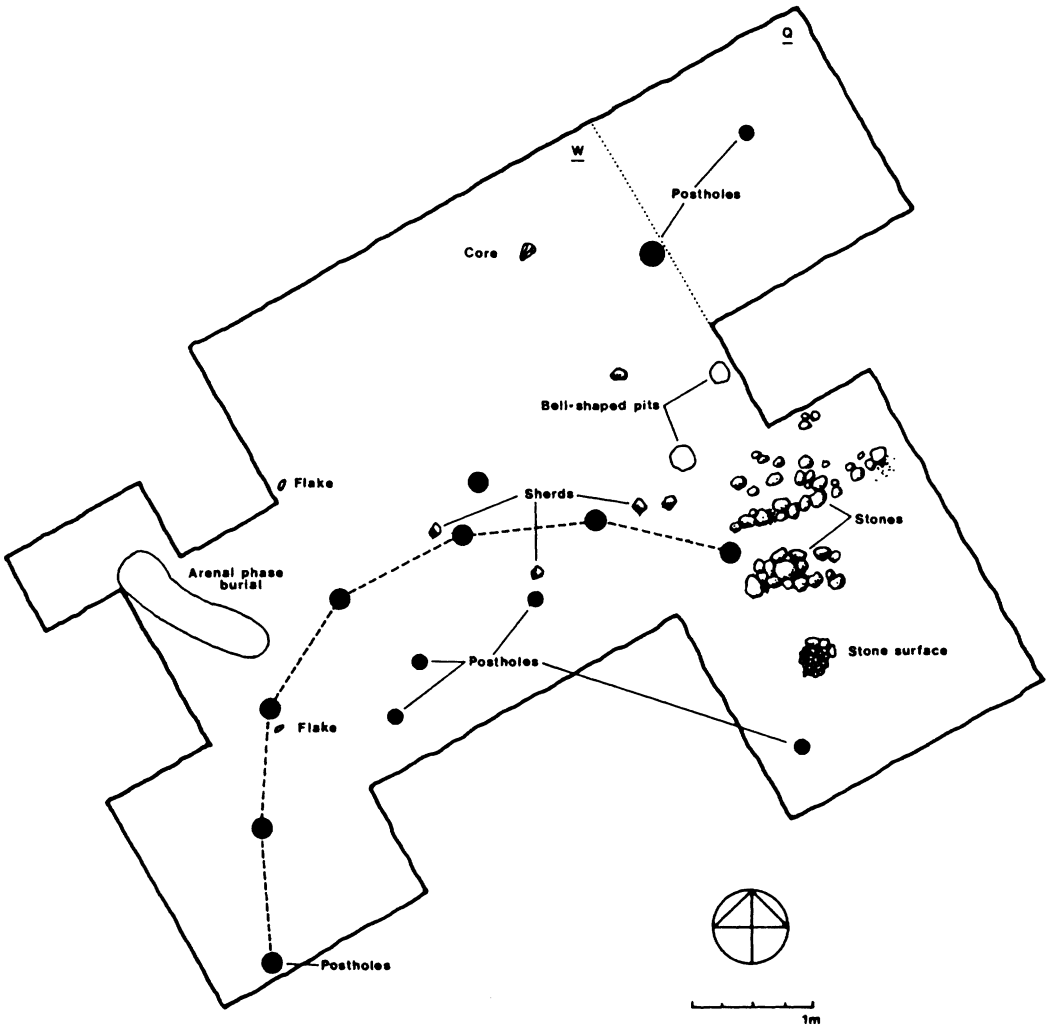

Figure 5. Plan of Tronadora-phase structure beneath Unit 61.

Evidence for other contemporaneous dwellings included postholes associated with heat-cracked rock and cooking stones. Fragments of burned daub indicate that the houses were made of wattle-and-daub, a common Early Formative building material (Flannery 1976). The large, evenly spaced postholes suggest that the structures were relatively substantial, and do not represent temporary shelters. One posthole, 20 cm in diameter and 45 cm deep, had embedded at its opening a flat, wedge-shaped rock that probably served to stabilize a loose post. Another contained pottery, probably used for the same purpose. Permanence of habitation is also suggested by the accumulation of stones in cooking areas, marked by fragments of burned clay, concentrations of charcoal, and sherds with charcoal residues.

Lithics from Unit 64 include chalcedony flake cores and bifacial thinning flakes, the tip of a red jasper bifacial point, and two sequent flakes from a polished stone celt. All but the latter were initially interpreted as the remains of Fortuna-phase activity, although they may well be later (Sheets 1994). Ceramics include rim sherds from *olla-tecomates* (round-sided bowl-like jars with restricted orifices), incurving-rim bowls, and a narrow-necked bottle, all of which have been identified as belonging to Tronadora-phase types.

The cultivation of maize is evidenced by both floral and artifactual remains. Three maize kernels were identified, one from the matrix of a posthole and the others in association with Tronadora pottery with charcoal residues. Cross-shaped maize phytoliths and a fragment of a maize cupule were found in association with oxidized stones (Matthews 1984; Piperno 1994). Maize phytoliths were also recovered from a concentration of heat-cracked stones (Bradley et al. 1984:Figure 6). A cache of four stacked broad and flat, pointed, chipped dacite "hoes" or unhafted digging tools was found next to one posthole (Sheets 1994). Mano and metate fragments provide additional evidence of maize processing.

Unit 61. The stratum, formed by a combination of airfall tephra and disturbances resulting from natural and human activity, contained a large number of cultural remains that were probably transported upward from Unit 64 or downward from Unit 60. Unit 61 provided the largest assemblage of Tronadora-phase ceramics. Several artifacts were found embedded in the unit's surface, including a nearly complete vessel of Zetillal Shell-Stamped (Hoopes 1987:Figure 6.4), found in an inverted position east of a line of six postholes. Lithic remains from this stratum consist of flake cores and a number of dacite celt flakes, one from a polished greenstone celt, which suggest the presence of celt-maintenance areas (Sheets 1994).

Unit 60. Excavations revealed a second living surface represented by postholes, heat-cracked rocks and cooking stones, flat-lying ceramics, flaked- and ground-stone artifacts, and macrobotanical remains at the interface of Units 61 and 60, 10–15 cm above the earlier house floor and separated from it by the tephra layer. Eight postholes at irregular intervals in a line 3.5 m long penetrated Unit 61. Heat-cracked rocks and stones scattered over an area of 3 m^2 have been identified as a cooking area on the basis of two fragments of carbonized maize kernels and sherds with charcoal residue. Artifacts associated with this feature included a small fragment of a knob-legged metate, a small biface fragment, flaked lithic debitage, and a number of decorated Tronadora sherds.

Elsewhere at the site, Unit 60 yielded heat-cracked rocks, flaked lithic debitage, and a predominance of Tronadora-phase ceramics. A single grain of maize (Clary 1994) and cross-shaped maize phytoliths (Piperno 1994) suggest that horticulture was being practiced.

Arenal-Phase Features and Assemblages. As noted above, strata between Unit 60 and Unit 50 consist of indistinct layers whose deposition spanned a period of several hundred years. With few exceptions, it was difficult to relate features identified in these levels to specific eruptive events of the Arenal volcano. In addition, these strata appear to have been heavily disturbed by both cultural and natural processes. Although some Tronadora-phase sherds were found in strata above Unit 60, the vast majority of material from these levels dates to the Arenal phase (500 B.C.–A.D. 500). Detailed discussion of this later phase, which is beyond the scope of this article, is presented by Hoopes (1987) and Bradley (1994).

Summary of the Tronadora Vieja Site

Artifacts and features in the lower levels of Tronadora Vieja indicate the presence of "household clusters" (Winter 1976) that include structures, domestic artifacts, cooking areas, and possible storage pits. Given the limited evidence, however, it is difficult to say how large the Tronadora-phase population of the site may have been. Volcanic eruptions may have temporarily disrupted activity at the site, but there is no evidence that they had lasting effects on either the site's habitability or the desire of populations to occupy this location. Several structures were buried by the emplacement of Unit 61 during a major volcanic explosion, but remains of other structures superimposed directly on top of this stratum indicate rapid reoccupation, perhaps by the occupants of the earlier structures. This rapid reoccupation, together with evidence for horticulture, indicates the existence of an early sedentary community at Tronadora Vieja.

Both Fortuna and Early Tronadora occupations appear to predate major eruptions of Chato and Arenal volcanoes, as evidenced by materials below Unit 61. The dates and stratigraphic positions of the samples from Tronadora Vieja support the interpretation of Unit 61 as tephra from Chato deposited ca. 1800 B.C. Given that Unit 61 was deposited rapidly during a single eruptive event, it would have been ideal for preserving cultural remains in a Pompeii-like depositional environment at locations closer to the tephra source. Whereas the shallowness of the tephra as deposited at

Tronadora Vieja prevented the preservation of houses such as those that have been revealed at Cerén, El Salvador (Sheets et al. 1990), there is an exciting possibility that other Early Formative dwellings are buried beneath deeper deposits at locations closer to the volcano.

TRONADORA-PHASE CERAMICS

Tronadora-phase pottery represents only a small portion of the total Proyecto Prehistórico Arenal assemblage. Out of 12,629 diagnostic sherds, only 620 diagnostic of the Tronadora phase were identified from 20 different sites, 77 percent from the Tronadora Vieja site alone. Of 61 categories used to classify the entire assemblage, only 13 apply to this phase.

The greatest obstacle to the interpretation of ceramics from Tronadora Vieja is the low density of sherds from excavated deposits. The total ceramic assemblage from Tronadora Vieja consists of 5,383 sherds, with only 137 (2.5 percent) from surface collections; however, diagnostic sherds constitute only 17 percent (901 sherds) of the entire sample. Diagnostic ceramics occur in 155 excavated lots, but no lot contains as many as 20 classifiable sherds of one of the 34 type categories utilized at the site. Only 681 sherds diagnostic as to group or type were recovered from excavations, and no vertical excavation yielded a high enough sherd density to permit construction of useful frequency curves within a single operation. Fortunately, the volcanic stratigraphy made it possible to group lots from different operations according to their stratigraphic associations. It is these grouped associations by stratum that provide the greatest support for chronological interpretations. Table 2 illustrates the stratigraphic associations of 455 sherds in 13 Tronadora-phase and 11 Arenal-phase type categories from 133 lots grouped according to their stratigraphic provenience. It should be apparent that Tronadora-phase sherds are concentrated in Units 60 and below, whereas Arenal-phase sherds are concentrated in the overlying levels.

Diagnostic Modes of the Tronadora Phase

Tronadora ceramics were constucted entirely by coiling rather than modeling. All sherds have carefully smoothed surfaces on both interiors and exteriors. A high-luster finish, found especially on red-slipped rims, was accomplished through stone burnishing.

Paste. Most Tronadora sherds are speckled with particles that probably represent basaltic andesite lapilli from volcanic eruptions (cf. Snarskis 1978:71). Fine tephras would have been available in well-sorted deposits at a number of locations. The high shrinkage of montmorillonite clays was counteracted by the addition of temper, and tephra is ubiquitous in ceramics from all phases in the Cordillera de Tilarán. Arenal-phase ceramics can be distinguished from Tronadora pottery by the presence of tabular hornblende crystals whose appearance may correspond to the deposition of El Tajo Unit 7 (Silencio Unit 54), which "marks Arenal's first eruption of dacitic magmas" (Melson 1984:47) and is characterized by a distinct deposition of hornblende-phyric dacitic lapilli.

Diagnostic Forms. Forms include (1) large *olla-tecomates* with exteriorly thickened, massive rounded or angular rims (R11; alphanumeric codes are included for cross-reference to those listed by Snarskis [1978]); (2) restricted-neck hemispherical bowls, thicker at the rim than on the sides (R6); (3) restricted-neck jars with exteriorly thickened rims; and (4) tall, cylindrical vessels with flat bases (Snarskis 1978:Figure 25a).

Diagnostic Decoration. Decoration includes (1) round-bottomed groove incising, often used to zone horizontal bands of red paint (D10) and areas of punctation or impression; (2) round or oblique punctation (D17); (3) red-painted strip appliqué emphasized by gouge incision; (4) wavy shell-edge stamping (D18); (5) deep, broad multiple incisions, sometimes infilled with red ocher; (6) punctations; (7) button-like appliqué or pastillage (Snarskis 1978:Figure 10jj); (8) cord marking (Snarskis 1978:Figure 24x); and (9) circular reed stamping (Snarskis 1978:Figure 24dd).

Ceramic Types of the Tronadora Phase

Five ceramic types have been formulated for the Tronadora phase. Because descriptions of these can be found elsewhere (Hoopes 1987, 1994), I will only make a few specific comments on each for comparative purposes.

Table 2. Stratigraphic Associations of Tronadora- and Arenal-Phase Sherds from Tronadora Vieja.

	Tronadora Phase													Arenal Phase										Tronadora	Arenal
Stratum	TB	RR	GRI	GR	TI	TGI	TGP	SS	ZIP	PUN	GEO	ARB	CIR	BIB	LPR	MI	MI:L	HZP	ERB	CBR	GI	TRI	LHB	N (%)	N (%)
30	1				1														3		1		4	2 (20)	8 (80)
50	1			1	1														1	1	—	1	1	3 (43)	4 (57)
Upper 50s	18	5	2	14	9	5	3	4			2			5	2	1	8	6	19	8	3	—	28	62 (44)	80 (56)
60	26	4	7	16	13	12	10	4	6	3	—	2	2	3	6	—	1	—	5	—	—	—	3	105 (85)	18 (15)
60/61	13	5	1	4	2	—	1	1	3	2	—	—	—	—	—	—	1	—	—	—	—	—	—	32 (97)	1 (3)
61	28	2	7	11	5	6	4	3	8	1	—	2	2	—	—	—	—	—	—	—	—	—	3	79 (96)	3 (4)
64	12	5	1	6	3	—	5	5	2	1	1	—	—	—	—	—	—	—	4	—	—	—	5	41 (82)	9 (18)
65	1	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	7 (88)	1 (13)
Total	100	21	18	58	34	23	23	17	19	7	3	4	4	8	8	1	10	6	33	9	4	1	44	331 (73)	124 (27)

Note: Key to type categories: TB = Tonjibe Beige; RR = red-rimmed beige vessels; GRI = horizontal groove-incised jars; GR = general groove-incision; TI = Tronadora Incised; TGI = Tajo Gouge-Incised; TGP = Tigra Grooved-Punctate; SS = general single-stroke shell stamping; ZIP = Zetillal Shell-Stamped; PUN = general heavy punctation; GEO = geometric groove-incision; ARB = Atlantic Red-Filled Black Group; CIR = circular reed stamping; BIB = Bocana Incised Bichrome; LPR = Las Palmas Red-on-beige; MI = Mojica Impressed: Mojica Variety; MI:L = Mojica Impressed: Laguna Variety; HZP = Huila Zoned-Punctate; TAM = Tamino Incised; ERB = Espinoza Red-Banded; CBR = Charco Black-on-red; GI = Guinea Incised; TRI = general trichrome; and LHB = Los Hermanos Beige.

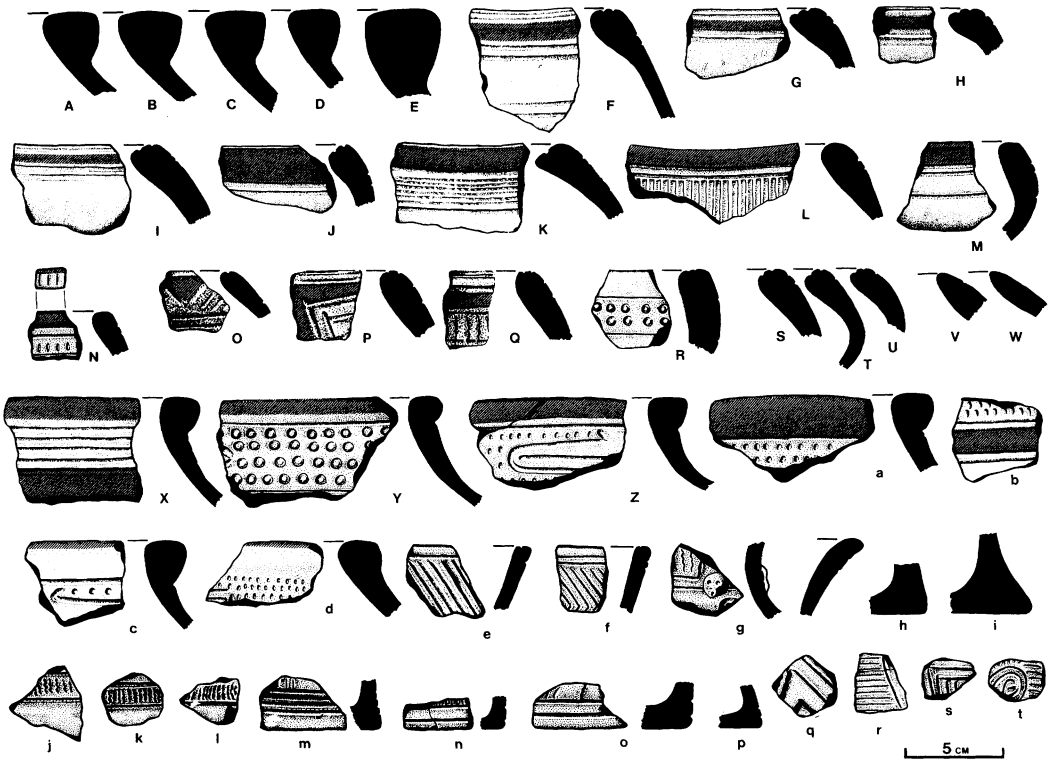

Figure 6. Tronadora-phase ceramics: (*A–E*) Tonjibe Beige; (*F–W*) Tronadora Incised; (*X–d*) Tigra Grooved-Punctate; (*e–f, m–t*) Atlantic Red-Filled Black; (*g–i*) Zetillal Shell-Stamped; (*j–l*) unnamed shell-stamped.

Tonjibe Beige (Figure 6A–E). The vessel form is an *olla-tecomate* (Snarskis 1978:335; R11), defined as an incurving-rim *tecomate* with a thick bolster on the rim exterior. The bolster strengthened the rim and served as a handle-like grip, making it more resistant to breakage. Rim diameters of 30 to 50 cm indicate that the vessels were massive containers, probably used for cooking, storage, and possibly for the brewing of *chicha* (ubiquitous in indigenous households of the region in historic and modern times). Cooking was probably done through the use of boiling stones, found in abundance at the site (Sheets 1994). The closest analogies to the bolstered-rim *olla-tecomates* outside of Costa Rica are found in late Early Formative assemblages in the Gulf Coast region of Veracruz, and include Mojonera Black (Coe and Diehl 1980:154, Figures 126k and 151s) and Aguatepec Thick (Coe and Diehl 1980:Figures 130b and 153) from the Chicharras and San Lorenzo phases (1250–900 B.C.) at San Lorenzo. Vessels of the latter are described as "extraordinarily large, basin-like bowls" with flat bottoms (Coe and Diehl 1980:156).

Tronadora Incised (Figures 6F–W and 7A–G). Tronadora Incised vessels are *tecomates*, incurving-rim bowls (cf. Snarskis 1978:Figure 69; rim-form mode R6), and shallow, round-bottomed dishes. Rims thickness, about twice that of the vessel wall, plus broad lip surface markedly differentiate the vessels from Barra- and Ocós-phase *tecomates* (Coe 1961; Green and Lowe 1967; Lowe 1975), whose rims are usually direct or tapered and relatively thin. Tronadora Incised vessels are much thicker and heavier, and may have been so constructed to withstand heavier usage than thin-walled *tecomates* could survive.

The principal decoration on this type is round-bottomed groove incision in combination with horizontally zoned areas of polished red slip. This is found principally on the upper surface of the vessel lip and the vessel exterior. Variations include geometric patterns of incised and painted areas

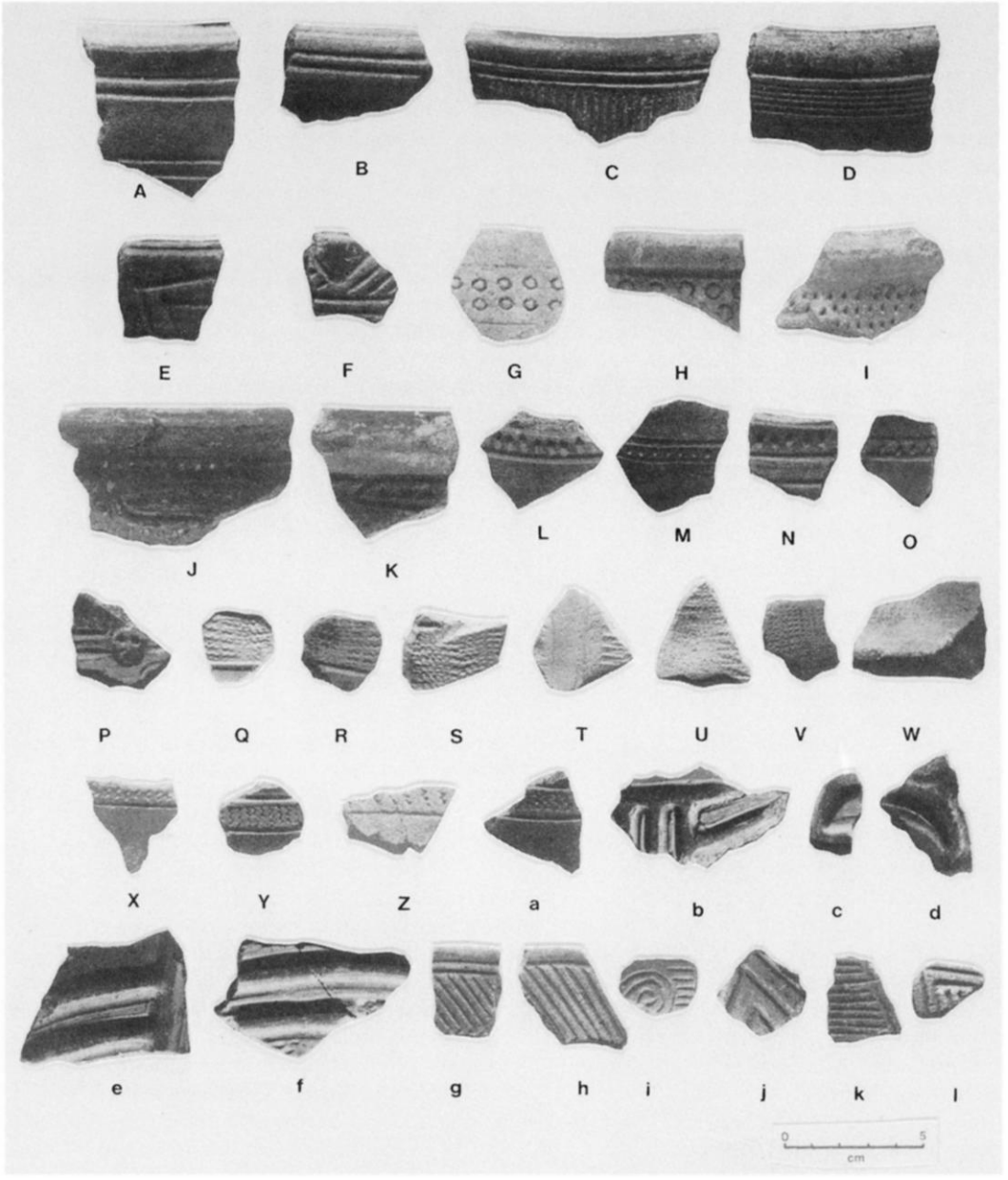

Figure 7. Tronadora ceramics: (*A–G*) Tronadora Incised; (*H–O*) Tigra Grooved-Punctate; (*P–W*) Zetillal Shell-Stamped; (*X–a*) unnamed shell-stamped; (*b–f*) Tajo Gouge-Incised; (*g–l*) Atlantic Red-Filled Black. Note: *Q*, *T*, and *U* are photographs of sherd impressions in plasticene. Photos by John Hoopes and Francine Mandel Sheets.

(Figure 6O–P); short, vertical shell-stamped marks (Figure 6Q); and reed stamping (Figure 6R). Edges of the wide grooves are rounded and smooth.

The incurving-rim bowl has been associated with a number of early ceramic-producing cultures in the Americas. Multiple grooving on the vessel lip appears on Ocós sherds from La Victoria (Coe 1961). Other examples of grooved lips appear in Ocós Black (Coe 1961:Figure 30e), Ocós Gray

(Coe 1961:Figure 30m), and Río Blanco Orange (Coe 1961:Figure 33e) in the Conchas phase at La Victoria. The example most similar to Tronadora Incised is from a Conchas Red-on-white *tecomate* with a single wide lip groove (Coe 1961:Figure 14). However, although round-bottomed grooving is an important decorative mode throughout the Early and Middle Formative sequence at La Victoria, in no example is it precisely duplicated by Tronadora Incised. Lip grooving occurs on Schettel Incised (Healy 1980:225–227; Norweb 1964) from the Rivas region of Nicaragua, Ometepe Island (Haberland 1966), and northwestern Guanacaste (Lange 1971; Lange and Scheidenhelm 1972), and there is probably a direct relation between Schettel Incised, dating to ca. 300 B.C.–A.D. 300, and the earlier Tronadora Incised. Other Costa Rican types that are very similar to Tronadora Incised include La Montaña Fugitive Red-on-cream and Chaparrón Red-on-brown (Snarskis 1978: Figures 12f–i, 22a–f, and 23w).

Tigra Grooved-Punctate (Figures 6X–d and 7H–O). The heavy punctation and incised decoration characteristic of this type appear on *tecomates*, incurving-rim bowls (Snarskis 1978:Figure 23s–u), and squat, short-necked jars. On bowls, the decoration appears immediately beneath the exterior rim, whereas on squat jars it is restricted to rims and necks. Many of the jars, the predominant necked vessel of the Tronadora phase, have carbonized material on the exterior, which indicates that they were used for cooking. Similar reed-impressed and incised, necked jars (Figure 6) also had traces of burned material on the exterior.

A squat, necked jar similar to examples from Tronadora Vieja (Figure 6) is known from Santa Rita, Belize (Clancy et al. 1985:Catalog No. 1), where it is associated with the Swasey phase. Similar sherds appear in Chaparrón assemblages, but not La Montaña. Tigra Grooved-Punctate is probably ancestral to Huila Zoned-Punctate (Baudez 1967:59; Healy 1980:129–130) in the Greater Nicoya ceramic sphere. Sherds of Tigra Grooved-Punctate are prominent in the assemblage from the dwelling beneath Unit 61 at Tronadora Vieja.

Zetillal Shell-Stamped (Figures 6g–i and 7P–W). The diagnostic Zetillal Shell-Stamped form (Hoopes 1987:Figure 6.4) is a tall cylindrical vessel with a flat base and hyperboloid profile. An almost complete example was recovered at Tronadora Vieja. Although missing its uppermost portion, it appears to have been about 25 cm tall and 10–15 cm in diameter. Snarskis (1978:70) has suggested these vessels may have served as drums, but this would have worked only if the vessel base were the playing surface. Without another aperture to allow air to escape, the vessel would not have resonated when a membrane was placed over the orifice. Presence of a thin charcoal residue in one vessel base suggests that something had been burned inside the vessel, which may indicate use as an *incensario* (incense burner). The tall, chimney-like shape would have promoted slow burning and smoke production, but the absence of a small aperture would have made this function very inefficient. Furthermore, the exteriors of vessel bases do not show evidence of smudging, and hence the charcoal may indicate use as a container. A third alternative is that the vessels were for preparing or serving special beverages; a beverage prepared from cacao, maize, manioc, or other ground vegetable product would have left a residue in the bottom of the vessel whose decay could be the source of these organic deposits.

The type is characterized by light impressions made with the wavy edge of a shell on the exterior vessel surface, often zoned with shallow groove incisions (Figures 6g–i and 7P–W). This includes both "rocker stamping" and single shell-edge impressions used to fill zones. Shell-edge rocker stamping is also found on Early Formative ceramics from southern Mesoamerica, including Ocós (Coe 1961:Figure 47a–y) and Early Ajálpan (MacNeish et al. 1970). Rocker stamping on Zetillal Shell-Stamped vessels is most similar to Ocós. A technique similar to single shell-edge impressions appears on sherds from the Gulf Coast of Veracruz (cf. García Payón 1966:Lámina XLIII, 1) and La Victoria (Coe 1961:Figure 49d′). Other methods of surface texturing on the same vessels forms in Tronadora-phase assemblages include cord marking or textile impressions, in some cases combined with groove-incised zoning, also similar to Ocós (cf. Coe 1961:Figure 49).

Vessels similar to Zetillal Shell-Stamped are shared by the Tronadora, Chaparrón, and La Montaña complexes. The only other nearly complete example comes from Zetillal de Ipís (16-ZIP) in the suburbs of San José (Snarskis 1978:69, Figure 25a). Two "scarified" vessels from the Chiriquí region of western Panamá illustrated by MacCurdy (1911:100) may be related, although one (MacCurdy

1911:Plate XXVIe) has tripod supports and the other (MacCurdy 1911:Plate XXVIa) is painted on the interior and exterior. These suggest that Tronadora-like complexes had a direct influence on the later "scarified wares" of Chiriquí, which have dates of ca. 100 B.C.

Vessels with thick-walled basal angles and flat bottoms disappear from central-highland and Atlantic-watershed assemblages in the phases that follow Chaparrón and La Montaña (Snarskis 1978:70). In Greater Nicoya, tall cylindrical forms associated with types such as Bocana Incised Bichrome: Diría Incised Variety (Abel-Vidor et al. 1987:49, Figure 8d) may be derived from Zetillal-like vessels.

Tajo Gouge-Incised (Figure 7b–f). This type is distinguished by narrow strips of appliqué in circumferential bands or as part of complex motifs composed of either curvilinear elements or perpendicular and parallel lines (Figure 7b–e). These are painted with a bright red slip, and the relief is emphasized by grooved, gouged, or scooped channels on either side of the strips. No vessel parts other than body sherds have been identified for this type, but all sherds appear to have come from large globular vessels. Until more complete examples of this type can be identified, little can be said about decorative motifs or vessel function.

Tajo Gouge-Incised may be related to the Mexican Gulf Coast type Calzadas Carved (Coe and Diehl 1980:162–170). Claude Baudez (personal communication 1985) agrees that there are similarities between Tajo Gouge-Incised and carved Olmec types, but rejects a parallel between this type and the Jaral-phase type Bográn Incised from central Honduras (Baudez and Becquelin 1972). Strip appliqué, usually notched or impressed, appears on early ceramics from Yarumela in the Ulua Valley of Honduras (Joesink-Mandeville 1987) and Parita Bay in Panama (Willey and McGimsey 1954), but in neither instance is this closely related to the decoration on Tajo Gouge-Incised.

Interregional Comparisons

The round-bottomed grooving, heavy punctation, shell-stamping, and red zoning found on Tronadora pottery are widespread in Nuclear America during the Early Formative period (Ford 1969; Hoopes 1992). In Panama, they appear on pottery from the Monagrillo and Sarigua phases (Cooke and Ranere 1992:Figures 7 and 8; Willey and McGimsey 1954). In Mesoamerica, they are diagnostic of Barra and Ocós on the Pacific coast of Guatemala and Chiapas (Coe 1961; Green and Lowe 1967; Lowe 1975), Ajálpan in the Tehuacán Valley (MacNeish et al. 1970), and other Early Formative assemblages (cf. Lowe 1978). Side-by-side comparisons with type collections of Early Formative ceramics from Panama and Guatemala make it clear that Costa Rican sherds are far more similar to the Guatemalan material. Some Ocós pottery is virtually identical to Tronadora, especially sherds with rocker-stamped and shell-stamped decoration, punctation, and groove incision. Two Tronadora sherds with red bands on the rim exterior (Figure 6V–W) represent the simple red-rimmed *tecomates* common to a number of mesoamerican Early Formative assemblages. Open bowls with bright red rims from both assemblages are close in form, color, and paste.

In addition to the predominant Tronadora complex bolstered-rim *olla-tecomate*, pointed and comma-shaped rim profiles are found in the assemblage from Tronadora Vieja (Figure 6). The broad distribution of *tecomates* in the earliest ceramic assemblages from a variety of regions has been a source of speculation regarding the diffusion of culture and ideas (Ford 1969; Myers 1978). The appearance of the *tecomate* form in combination with other distinctive Early Formative modes in the Tronadora assemblage suggests the participation of the Cordilleran region of Costa Rica in much larger cultural patterns that appear throughout Nuclear America between 2000 and 1500 B.C. (Hoopes 1992).

Sample size is inadequate for more than an impressionistic chronological subdivision of the Tronadora phase. Modes shared by Tronadora, Barra, and Ocós (as well as early South American complexes such as Tesca, Canapote, Barlovento, and Machalilla [Bischof 1972; Meggers et al. 1965]) characterize the Early Tronadora phase (2000–1000 B.C.), when Tonjibe Beige, Tronadora Incised, and Zetillal Shell-Stamped first appeared. The Late Tronadora phase (1000–500 B.C.) is characterized by modes transitional into Loma B Zoned Bichrome (Early Arenal) types, especially the combinations of grooving and bichroming found on the type Bocana Incised Bichrome. Given a date

of ca. 1000 B.C. for Loma B, this type is likely to have emerged during the Late Tronadora phase. Tronadora modes similar to those of other Middle Formative ceramics, such as the distinctive Tajo Gouge-Incised decoration and infilling with ocher (Figure 6, Snarskis's "Atlantic Red-Filled Black" category), are also likely to date to the Late Tronadora phase (1000–500 B.C.). The continued usage of round-bottomed grooving and punctation in the subsequent Arenal phase also blurs the transition between Tronadora and Arenal. There are several Early Arenal characteristics *not* found in Tronadora. These include: vessel supports; a predominance of vertical, rather than horizontal incision; red painting that is not zoned with incision; and multiple, "combed" incisions made with a single instrument.

DATING THE TRONADORA PHASE

Nine ^{14}C dates have been obtained on charcoal samples from Tronadora Vieja (Table 1). Four pertain to the preceramic Fortuna phase and five are from ceramic-bearing contexts. Three of the dates associated with Tronadora-phase ceramics are earlier by 1,000 years than any other accepted dates for Costa Rican pottery. They compare favorably, however, with dates for similar Early Formative complexes in Ecuador, Panama, Colombia, and Guatemala, and confirm the participation of Costa Rican cultures in developmental patterns widespread throughout Central America and northwestern South America at this time.

As noted above, two ^{14}C assays date the beginning of the Tronadora phase: 2460–1790 cal B.C. [Tx-5277] and 2850–990 cal B.C. [Tx-5279]. Tx-5277 comes from a 20-g fragment of charcoal from the upper 5 cm of Unit 65. It was found in direct association with sherds, one of which had charcoal adhering to its interior. Tx-5279 comes from the floor of a prehistoric structure at the contact of Units 64 and 61, also associated with ceramics. A third, problematic date is 3350–2910 cal B.C. [Tx-5276: 4450 ± 70 B.P.]. Although it was directly associated with a hearth containing sherds (one with carbon residue), lithic debitage, and a charred maize kernel at the interface of Units 61 and 60 (thus higher in the stratigraphy than Tx-5277 or Tx-5279), it is considered to be a thousand years too early. The dendro-corrected 95 percent confidence interval of Tx-5277 falls within that of Tx-5279, and the calibrated overlap range of 2460–1790 B.C. places the inception of the Tronadora phase at ca. 2000 B.C.

The Tronadora phase is also dated by the evidence from the regional volcanic stratigraphy. Ceramics and features pertaining to this phase were found beneath Unit 61, believed to have been deposited by the Chato volcano ca. 1800 B.C. They were also found within Unit 61 and Unit 60, the latter considered to be a related paleosol that developed prior to the first eruption of Arenal. If Unit 55 corresponds to the first eruption of the Arenal volcano ca. 900 B.C., the Tronadora-phase occupation of Tronadora Vieja can be dated on stratigraphic grounds to approximately 1800–900 B.C. Without additional dates, it is impossible to narrow this range.

It is interesting to note that Hurtado de Mendoza and Alvarado Induni (1988:82) report three ^{14}C dates of 1900–1670 cal B.C. [Beta-30986: 3470 ± 50 B.P.], 1880–1520 cal B.C. [Beta-30985: 3410 ± 60 B.P.], and 1920–1460 cal B.C. [GX-12885: 3400 ± 90 B.P.] from hearths associated with an aceramic lithic workshop at Mogote, on the southwest slopes of the Miravalles volcano. In a situation surprisingly similar to Tronadora Vieja, the earliest archaeological features were embedded in the surface of the Aguacate Formation (Unit 65) and capped by a thick layer of volcanic tephra. The tephra at Mogote, 65 km northwest of the Arenal and Chato volcanoes, was probably not deposited by the same eruption that deposited Unit 61. Dates from the buried hearths are, however, very similar to those for Tronadora features. Hurtado suggests that the Mogote features are Archaic in date, but they may in fact represent a specialized site for lithic production contemporaneous with the Early Formative occupation at Tronadora Vieja.

Outside of the Arenal Basin, ceramics identical to Tronadora pottery have been discovered at Palenque Tonjibe, near San Ramón (collected by the late Enrique Herra), and at the site of La Pochota, in the Tempisque Valley (Odio O. 1991). Tronadora is also closely related to ceramic complexes in other parts of Nicaragua and Costa Rica. These include (in order of similarity) Naranjo, Chaparrón, Dinarte, Loma B, La Montaña, Barba, and Curré. Of these, only La Montaña, Naranjo,

and Loma B have associated ^{14}C dates. A date of 1400–830 cal B.C. [UCLA-2167F: 2910 ± 100 B.P.] from the site of La Fábrica (Lange and Stone 1984:Appendix 5) is the only one from this period in the central-highlands region, but its association with early ceramic forms is unclear. A summary of the dating of roughly contemporaneous complexes follows.

There are five dates for early ceramics at La Montaña (Table 1). The earliest is 2200–1410 cal B.C. [UCLA-2113A: 3465 ± 160 B.P.]. Three others overlap from 800 to 400 B.C. at the 2-sigma range; the fifth may have been contaminated by charcoal from a later occupation. Although the earliest was initially rejected as being too early (Snarskis 1978:107), similarities between Tronadora and La Montaña ceramics now suggest it may, in fact, be accurate.

At the Méndez site on the Río Naranjo, Norr (1986) placed ceramics that were similar to Chaparrón in the Naranjo phase, dated to 800–300 B.C. (uncalibrated). There are two dates from this site. The first, 1970–1680 cal B.C. [UCLA-2167A: 3500 ± 60 B.P.], comes from wood charcoal obtained from a "culturally sterile stratum under Mound I," and the second, 400–160 cal B.C. [UCLA-2163: 2250 ± 60 B.P.], comes from "an occupational level at ground surface at the time . . . Mound I was constructed" (Norr 1986:140). Sherds from the lowest levels (Norr 1986:Figure 9.9a–c) are identical to those from Tronadora Vieja. Norr interprets UCLA-2167A as dating the early limit of the site's occupation. Although this sample was not in direct association with pottery, similarities between Naranjo and Tronadora ceramics suggest that Méndez had an occupation coeval with the Tronadora phase.

The earliest date for pottery on the Pacific Coast of Greater Nicoya comes from the Vidor site (Lange 1980:35). Decorated sherds in the deeper levels were associated with a date of 1250–810 cal B.C. [UCLA-2177A: 2830 ± 80 B.P.]. Because of the appearance of types such as Bocana Incised Bichrome in Loma B levels, this phase is considered to overlap with Late Tronadora ca. 1000 B.C. In Nicaragua, Haberland (1992:71) suggests a date of 1500 B.C. for Dinarte-phase ceramics on Ometepe Island on the basis of stylistic comparisons with early mesoamerican pottery. Dinarte-phase ceramics remain poorly illustrated (Haberland 1966), but one example appears to be a cylindrical vessel similar to Zetillal Shell-Stamped. Haberland (1992:71) considers Tronadora and Dinarte ceramics to be contemporaneous.

The fact that Tronadora ceramics have many features not known from Mesoamerica indicates a strong degree of regionalization, whereas several important similarities between Tronadora and Ocós ceramics suggest that northwestern Costa Rica, although culturally distinct, was participating in a larger mesoamerican–Central American interaction sphere during the Early Formative period. The earliest decorated ceramics in Mesoamerica appear with the Barra phase of coastal Chiapas, with three dates from Paso de la Amada (2180–1320 B.C. [B-14244: 3420 ± 170 B.P.], 2270–1060 B.C. [I-8161: 3360 ± 225 B.P.], and 1960–1200 B.C. [I-8162: 3300 ± 160 B.P.]) that overlap from 1960 to 1320 B.C. at the 95 percent confidence interval (Blake 1991; Ceja T. 1985; Lowe 1975). Together, Barra and the succeeding Locona and Ocós phases span approximately 1850 to 1350 B.C. We still know too little about the Early Formative period in Costa Rica to be able to say what type of interchange was occurring. Nevertheless, this new information helps resolve a longstanding disjunction between the dates for "Olmec"-style artifacts reportedly found in southern Central America and the earliest portion of the Costa Rican ceramic sequence.

Phase Subdivision

The division of the Tronadora phase into Early and Late facets results from a desire to subdivide a long (2,500-year) cultural phase. Despite careful analysis of ceramics from the lower strata at Tronadora Vieja, it has not been possible to identify characteristics diagnostic of each subphase. It is, however, possible to suggest general trends. The choice of 1000 B.C. as a tentative boundary is based in part on the date of 1250–810 cal B.C. [UCLA-2177A] for Loma B at the Vidor site. Late Tronadora ceramics are considered transitional between the Early Tronadora-Chaparrón-La Montaña complexes and "Palmar Ware" Loma B types such as Schettel Incised, Bocana Incised Bichrome, and Toya Zoned Incised (Lange 1984). This division is intended to emphasize contemporaneity and continuity between the Late Tronadora phase and the earliest ceramics of coastal regions of Greater Nicoya.

Terminal Date

The terminal date for the Tronadora phase was initially based on an estimate of 500 B.C. for the date of deposition of Unit 55 (El Tajo Unit 8), an event which is neither well understood nor well documented, and the two earliest dates associated with Arenal-phase ceramics. These are: 1930 cal B.C.–cal A.D. 670 [Tx-5280: 2470 ± 560 B.P.] and 820 cal B.C.–cal A.D. 10 [Tx-5271: 2340 ± 170 B.P.], neither of which is very precise, although both average to ca. 400–500 B.C. The three other dates associated with early Zoned Bichrome material in Guanacaste cluster between 300 and 250 cal B.C. These are the 400–160 cal B.C. [UCLA-2163] date from Sitio Méndez cited above (Norr 1986:140), a date of 390–60 cal B.C. [UCLA-2177B: 2200 ± 60 B.P.] from Orso-phase deposits at Vidor (Lange 1984), and a date of 400–40 cal B.C. [GsY-100: 2195 ± 130 B.P.] from Catalina-phase deposits at Ortega, a weighted average of two assays on the same sample (2221 ± 100 B.P. and 2168 ± 98 B.P.), which also yielded a later date of A.D. 210–540 [Y-850: 1700 ± 70 B.P.] (Baudez 1967:26–27).

CONCLUSIONS

Tronadora ceramics precede and are ancestral to the earliest Zoned Bichrome ceramics of the Greater Nicoya subregion (Lange 1980). They are closely related to Dinarte ceramics from Nicaragua (Haberland 1966, 1992) and Costa Rican complexes such as Chaparrón, La Montaña, and Barba (Snarskis 1978), as well as Curré pottery of southern Costa Rica (Corrales U. 1989). Tronadora pottery does not, however, represent an incipient ceramic industry. Rather, the sophistication of vessel form and decoration suggests that it is the outgrowth of a still-undefined period of experimentation. The questions of whether ceramic technology developed locally or diffused from cultures to the north or south, and when these events occurred, remain unanswered. There are no ceramic traditions in Mesoamerica that are clearly antecedent to Tronadora; the stylistically similar Barra and Ocós complexes are contemporaneous, not earlier. To the south, Monagrillo pottery predates Tronadora, but Tronadora is similar to Monagrillo and the subsequent Sarigua pottery only in specific decorative modes (red rims, groove incision, shell stamping).

How do we interpret the Tronadora complex? The closest affinities of both Tronadora and the related Chaparrón pottery are with southern Mesoamerica. In spite of notable homologies between Tronadora and Ocós, however, there are significant differences. Bolstered rims (Tonjibe Beige) and tall, cylindrical vessels (Zetillal Shell-Stamped) are absent in Early Formative complexes outside of Costa Rica. Furthermore, the earliest dates for Barra (Clark 1991; Lowe 1975) are still slightly younger than those for Tronadora. If there is a linear relation between the Costa Rican and mesoamerican complexes, the influence is from south to north, not the reverse.

At present, an argument that mesoamerican ceramic traditions diffused northward from Costa Rica would be highly presumptuous. Recent excavations by Clark and Blake (Blake 1991; Clark 1991) have yielded evidence for possible "chief's residences" during Ocós/Cherla times in coastal Soconusco, which suggests that Early Formative societies in Mesoamerica were more highly centralized than contemporaneous ones in Costa Rica. This situation was probably not conducive to influence from south to north. Important components of mesoamerican complexes that are rare or absent in Tronadora assemblages, such as flat-based bowls and true *tecomates*, have local precedents in ground-stone artifacts and gourds, and a consensus is emerging that pottery was developed independently. Even after the appearance of a mature ceramic technology, other significant differences are apparent, among which is the use of solid ceramic figurines. These objects, clearly important for early peoples of Mesoamerica, have not yet been found in association with any of the earliest Costa Rican ceramic complexes.

The very early dates for ceramic technology in northwestern South America and Panama might suggest that Tronadora pottery originated in the south. Tronadora is, however, quite different from either Barlovento or Valdivia, the most likely sources of South American influence. It also shares only a few similarities with the Monagrillo pottery of Panama, which Cooke and Ranere (1992: 270) believe to be wholly independent of South American styles.

Questions about the relative importance of maize make this issue even more complex. It is tempting to attribute the introduction of maize in Costa Rica, and its use in the Tronadora phase,

to contacts with Mesoamerica. Given ceramic similarities, coastal Chiapas would be the most likely source. Blake et al. (1992) argue, however, that maize was relatively unimportant in the Barra, Locona, and Ocós phases, which have yielded little direct evidence for maize cultivation. If Mesoamerica was the source for Tronadora ceramics and maize cultivation, the cultures responsible for their introduction have not yet been identified. Until they are, the hypothesis that Tronadora pottery represents an early, regionalized manifestation of Early Formative culture—rather than an introduction from either Mesoamerica or South America—merits strong consideration.

Tronadora ceramics are best interpreted as the manifestation in Costa Rica of broad patterns of stylistic and technological development in the Early Formative from an as yet undefined cultural substrate, rather than the result of a diffusion of an early ceramic style from somewhere else. The great variation among ceramic complexes throughout Nuclear America at this time argues for a high degree of regionalization as early as 2000 B.C. This in turn signals the existence of fundamental cultural differences relevant to the divergent developmental trajectories of societies in southern Central America and those in areas of high civilization. Among these are the persistence in Costa Rica of decentralized forms of social organization until at least the first centuries of the Christian Era.

The existence of an Early Formative village dating to ca. 2000–1800 B.C. buried beneath a substantial tephra deposit strongly suggests that other similar sites may exist in the Arenal region. Such sites would be important for understanding early sedentary societies in tropical regions, and their discovery should be a priority of future research. The eroding shoreline of Lake Arenal nearest the volcanoes should be surveyed frequently, and any construction activity in this area that exposes deep tephra deposits should be carefully monitored.

Acknowledgments. This research was conducted under the auspices of the Proyecto Prehistórico Arenal, directed by Payson Sheets (University of Colorado) and funded by grants from the National Science Foundation (BNS 83-10599 and BNS 84-19879) and the National Geographic Society (#2728-83). Supplementary support was provided by the Owens Fund of the Bowditch Bequest, Harvard University, administered by Gordon R. Willey. Archaeology in the Arenal region would not have been possible without the permission of the National Museum of Costa Rica and the assistance of administrators Lorena San Román and Lorena Aguilar. The assistance of the Instituto Costarricense de Electricidad, on whose property surveys and excavations were conducted, is gratefully acknowledged. The encouragement and expert guidance of Payson Sheets and Gordon R. Willey were crucial to the success of this research, as was the hard work of the other Proyecto Prehistórico Arenal participants: Aida Blanco Vargas, John Bradley, Roberta Klausing Bradley, Marc Chenault, Nancy Mahaney Chenault, Karen Clary, Elizabeth Knapp, Meredith Matthews, Marilynn Mueller, Dolores Piperno, Tom Sever, Francine Mandel Sheets, Gilberto Vargas, and several Costa Rican laborers. William Melson and Andrea Borgia provided assistance with interpretation of the volcanic stratigraphy. Claude Baudez, Francisco Corrales, Wolfgang Haberland, Paul Healy, Rosemary Joyce, Fred Lange, R. S. MacNeish, Izumi Shimada, and Michael Snarskis provided invaluable assistance with ceramic comparisons. Figure 1 was prepared by Barbara Bolton, Figure 3 was drafted by Oliver Rudford, Figure 5 was drawn by the author, and Figure 6 was drawn by the author with Paul Jaeckel. The author, of course, accepts responsibility for any errors of fact or logic.

REFERENCES CITED

Abel-Vidor, S., C. Baudez, R. Bishop, L. Bonilla, M. Calvo, W. Creamer, J. Day, J. V. Guerrero, P. Healy, J. Hoopes, F. Lange, S. Salgado, R. Stroessner, and A. Tillet
1987 Principales tipos cerámicos y variedades de la Gran Nicoya. *Vínculos* 13:35–318.

Aguilar P., C.
1984 *Introducción a la arqueología de la región del Volcán Arenal: Tefraestratigrafía y secuencia cultural.* Anales de la Academia de Geografía e Historia de Costa Rica, San José.

Barrantes, R., P. E. Smouse, H. W. Mohrenweiser, H. Gershowitz, J. Azofeifa, T. D. Arias, and J. V. Neel
1990 Microevolution in Lower Central America: Genetic Characterization of the Chibcha-Speaking Groups of Costa Rica and Panama, and a Taxonomy Based on Genetics, Linguistics, and Geography. *American Journal of Human Genetics* 46:63–84.

Baudez, C. F.
1967 *Réchèrches archéologiques dans la vallée du Tempisque, Guanacaste, Costa Rica.* Travaux et Memoires de l'Institut des Hautes Etudes de l'Amérique Latine Vol. 18. Centre National de la Réchèrche Scientifique, Paris.

Baudez, C. F., and P. Becquelin
1972 *Archéologie de Los Naranjos, Honduras.* Collection Etudes Mésoaméricaines Vol. 2. Mission Archéologique et Ethnologique Française au Mexique, Paris.

Baudez, C. F., and M. D. Coe
1962 Archaeological Sequences in Northwestern Costa Rica. *Proceedings of the 34th International Congress of Americanists* 1:366–373. Vienna.
Bischof, H.
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.
Blake, M.
1991 An Emerging Early Formative Chiefdom at Paso de la Amada, Chiapas, Mexico. In *The Formation of Complex Society in Southeastern Mesoamerica*, edited by W. R. Fowler, Jr., pp. 27–46. CRC Press, Boca Raton, Florida.
Blake, M., B. Chisolm, J. Clark, and K. Mudar
1992 Non-Agrarian Staples and Agricultural Supplements: Early Formative Subsistence in the Soconusco Region, Mexico. In *Transitions to Agriculture in Prehistory*, edited by A. B. Gebauer and T. D. Price, pp. 133–151. Monographs in World Prehistory No. 4. Prehistory Press, Madison.
Borgia, A., C. Poore, M. J. Carr, W. G. Melson, and G. E. Alvarado
1988 Structural, Stratigraphic, and Petrological Aspects of the Arenal-Chato Volcanic System, Costa Rica: Evolution of a Young Stratovolcanic Complex. *Bulletin of Volcanology* 50:86–105.
Bradley, J. E.
1994 Tronadora Vieja: An Archaic and Early Formative Site in the Arenal Region. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 73–86. University of Texas Press, Austin, in press.
Bradley, J. E., J. W. Hoopes, and P. D. Sheets
1984 Lake Site Testing Program. In *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984*, edited by P. D. Sheets and M. Mueller, pp. 187–192. Vínculos 10.
Ceja T., J. F.
1985 *Paso de la Amada: An Early Preclassic Site in the Soconusco, Chiapas.* Papers No. 49. New World Archaeological Foundation, Brigham Young University, Provo, Utah.
Chapman, A.
1960 *Los nicarao y los chorotega según los fuentes históricas.* Serie História y Geografía No. 4. Universidad de Costa Rica, San José.
Clancy, F. S., C. C. Coggins, T. P. Culbert, C. Gallenkamp, P. D. Harrison, and J. A. Sabloff
1985 *Maya: Treasures of an Ancient Civilization.* Abrams, New York.
Clark, J. E.
1991 The Beginnings of Mesoamerica: Apologia for the Soconusco Early Formative. In *The Formation of Complex Society in Southeastern Mesoamerica*, edited by W. R. Fowler, Jr., pp. 13–26. CRC Press, Boca Raton, Florida.
Clary, K. H.
1994 Pollen Evidence for Prehistoric Environment and Subsistence Activities. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 293–302. University of Texas Press, Austin, in press.
Coe, M. D.
1961 *La Victoria, an Early Site on the Pacific Coast of Guatemala.* Papers of the Peabody Museum of Archaeology and Ethnology Vol. 53. Harvard University, Cambridge, Massachusetts.
Coe, M. D., and C. F. Baudez
1961 The Zoned Bichrome Period in Northwestern Costa Rica. *American Antiquity* 26:505–515.
Coe, M. D., and R. Diehl
1980 *The Archaeology of San Lorenzo Tenochtitlan.* In the Land of the Olmec, vol. 1. University of Texas Press, Austin.
Cooke, R. G.
1984 Archaeological Research in Central and Eastern Panama: A Review of Some Problems. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 263–302. University of New Mexico Press, Albuquerque.
Cooke, R. G., and A. J. Ranere
1992 The Origin of Wealth and Hierarchy in the Central Region of Panama (12,000–2,000 BP), with Observations on Its Relevance to the History and Phylogeny of Chibchan-Speaking Polities in Panama and Elsewhere. In *Wealth and Hierarchy in the Intermediate Area*, edited by F. W. Lange, pp. 243–316. Dumbarton Oaks Research Library and Collection, Washington, D.C.
Corrales U., F.
1985 Prosepección y excavaciones estratigráficas en el Sitio Curré (P-62-Ce), Valle Diquís, Costa Rica. *Vínculos* 11:1–16.
1989 *La ocupación agrícola temprana del sitio arqueológico Curré, valle del Diquís.* Tesis de Licenciatura, Escuela de Antropología y Sociología, Facultad de Ciencias Sociales, Universidad de Costa Rica, San José.
Eidt, R. C.
1984 *Advances in Abandoned Settlement Analysis: Application to Prehistoric Anthrosols in Colombia, South America.* Center for Latin America, University of Wisconsin, Milwaukee.

Flannery, K. V. (editor)
1976 *The Early Mesoamerican Village.* Academic Press, New York.
Fonseca Z., O.
1992 *Historia antigua de Costa Rica: Surgimiento y caracterización de la primera civilización costarricense.* Editorial de la Universidad de Costa Rica, San José.
Ford, J. A.
1969 *A Comparison of Formative Cultures in the Americas: Diffusion or the Psychic Unity of Man?* Smithsonian Contributions to Anthropology Vol. 11. Smithsonian Institution, Washington, D.C.
Fowler, W. R., Jr.
1989 *The Cultural Evolution of Ancient Nahua Civilizations: The Pipil-Nicarao of Central America.* University of Oklahoma Press, Norman.
García Payón, J.
1966 *Prehistória de Mesoamérica; excavaciones en Trapiche y Chalahuite, Veracrúz, Mexico, 1942, 1951 y 1959.* Cuadernos de la Facultad Filosofía, Letras y Ciencias No. 31. Universidad Veracruzana, Jalapa.
Green, D. F., and G. W. Lowe
1967 *Altamira and Padre Piedra, Early Preclassic Sites in Chiapas, Mexico.* Papers No. 20. New World Archaeological Foundation, Brigham Young University, Provo, Utah.
Haberland, W.
1966 Early Phases on Ometepe Island, Nicaragua. *Proceedings of the 36th International Congress of Americanists* 1:399–403. Editorial Católica Española, Seville.
1978 Lower Central America. In *Chronologies in New World Archaeology*, edited by R. E. Taylor and C. W. Meighan, pp. 395–430. Academic Press, New York.
1986 Settlement Patterns and Cultural History of Ometepe Island, Nicaragua: A Preliminary Sketch. In *Prehistoric Settlement Patterns in Costa Rica*, edited by F. W. Lange and L. Norr, pp. 369–386. Journal of the Steward Anthropological Society 14. Department of Anthropology, University of Illinois, Urbana–Champaign.
1992 The Culture History of Ometepe Island: Preliminary Sketch (Survey and Excavations, 1962–1963). In *The Archaeology of Pacific Nicaragua*, edited by F. W. Lange, P. D. Sheets, A. Martínez, and S. Abel-Vidor, pp. 63–117. University of New Mexico Press, Albuquerque.
Hartshorn, G. S.
1983 Plants: Introduction. In *Costa Rican Natural History*, edited by D. Jantzen, pp. 118–157. University of Chicago Press, Chicago.
Healy, P. F.
1980 *Archaeology of the Rivas Region, Nicaragua.* Wilfred Laurier University Press, Waterloo, Ontario.
Hoopes, J. W.
1984 A Preliminary Ceramic Sequence for the Cuenca de Arenal, Cordillera de Tilarán Region, Costa Rica. In *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984*, edited by P. D. Sheets and M. Mueller, pp. 129–147. Vínculos 10.
1985 El complejo Tronadora: Cerámica del período Formativo Medio en la Cuenca de Arenal, Guanacaste, Costa Rica. *Vínculos* 11:111–118.
1987 *Early Ceramics and the Origins of Village Life in Lower Central America.* Ph.D. dissertation, Harvard University. University Microfilms, Ann Arbor.
1991 The Isthmian Alternative: Reconstructing Patterns of Social Organization in Formative Costa Rica. In *The Formation of Complex Society in Southeastern Mesoamerica*, edited by W. R. Fowler, Jr., pp. 171–192. CRC Press, Boca Raton, Florida.
1992 Early Formative Cultures in the Intermediate Area: A Background to the Emergence of Social Complexity. In *Wealth and Hierarchy in the Intermediate Area*, edited by F. W. Lange, pp. 43–84. Dumbarton Oaks Research Library and Collection, Washington, D.C.
1994 Ceramic Analysis and Culture History in the Arenal Region. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 158–210. University of Texas Press, Austin, in press.
Hoopes, J. W., and M. L. Chenault
1994 Excavations at Sitio Bolívar: A Late Formative Village in the Arenal Basin. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 87–105. University of Texas Press, Austin, in press.
Hoopes, J. W., and G. McCafferty
1989 Out of Mexico: An Archaeological Evaluation of the Migration Legends of Greater Nicoya. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, Atlanta.
Hurtado de Mendoza, L., and G. Alvarado Induni
1988 Datos arqueológicos y vulcanológicos de la región del Volcán Miravalles, Costa Rica. *Vínculos* 14: 77–90.
Joesink-Mandeville, L. R. V.
1987 Yarumela, Honduras: Formative Period Cultural Conservatism and Diffusion. In *Interaction on the Southeast Mesoamerican Frontier*, edited by E. Robinson, pp. 196–214. BAR International Series 327(i). British Archaeological Reports, Oxford.

Lange, F. W.
1971 *Cultural History of the Sapoá River Valley, Costa Rica.* Occasional Paper No. 4. Logan Museum of Anthropology, Beloit College, Beloit, Wisconsin.
1980 The Formative Zoned Bichrome Period in Northwestern Costa Rica (800 B.C. to A.D. 500), Based on Excavations at the Vidor Site, Bay of Culebra. *Vínculos* 6:33–42.
1984 The Greater Nicoya Archaeological Subarea. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 165–194. University of New Mexico Press, Albuquerque.
Lange, F. W., and K. Scheidenhelm
1972 The Salvage Archaeology of a Zoned Bichrome Cemetery. *American Antiquity* 37:240–245.
Lange, F. W., and D. Z. Stone (editors)
1984 *The Archaeology of Lower Central America.* University of New Mexico Press, Albuquerque.
Lowe, G. W.
1975 *The Early Preclassic Barra Phase of Altamira, Chiapas: A Review with New Data.* Papers No. 38. New World Archaeological Foundation, Provo, Utah.
1978 Eastern Mesoamerica. In *Chronologies in New World Archaeology*, edited by R. E. Taylor and C. W. Meighan, pp. 331–393. Academic Press, New York.
MacCurdy, G. G.
1911 *A Study of Chiriquian Antiquities.* Memoirs of the Connecticut Academy of the Arts and Sciences Vol. 3. New Haven.
MacNeish, R. S., F. A. Peterson, and K. V. Flannery
1970 *Ceramics.* Prehistory of the Tehuacán Valley, vol. 3. University of Texas Press, Austin.
Matthews, M.
1984 Results of Macrobotanical Analysis for the Proyecto Prehistórico Arenal: Preliminary Evidence of Resource Use and Subsistence Strategies. In *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984*, edited by P. D. Sheets and M. Mueller, pp. 193–205. Vínculos 10.
Meggers, B. J., C. Evans, and E. Estrada
1965 *Early Formative Period of Coastal Ecuador: The Valdivia and Machalilla Phases.* Smithsonian Contributions to Anthropology Vol. 1. Smithsonian Institution, Washington, D.C.
Melson, W. G.
1982 Alternation Between Acidic and Basic Magmas in Major Explosive Eruptions of Arenal Volcano, Costa Rica. *Boletín de Vulcanología* 14:65–74.
1984 Prehistoric Eruptions of Arenal Volcano, Costa Rica. In *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984*, edited by P. D. Sheets and M. Mueller, pp. 35–59. Vínculos 10.
1994 The Eruption of 1968 and Tephra Stratigraphy of Arenal Volcano. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 24–47. University of Texas Press, Austin, in press.
Melson, W. G., and R. Saenz
1968 *The 1968 Eruption of Volcano Arenal: Preliminary Summary of Field and Laboratory Studies.* Report No. 7. Smithsonian Center for Short-Lived Phenomena, Washington, D.C.
1973 Volume, Energy, and Cyclicity of Eruptions of Arenal Volcano, Costa Rica. *Bulletin Volcanologique* 37:416–437.
Melson, W. G., J. H. Barquero, R. R. Saenz, and E. Fernandez
1986 Erupciones explosivas de importancia en volcanes de Costa Rica. *Boletín de Vucanología* 16:15–19.
Mueller, M.
1984 Laguna de Arenal Shoreline Survey. In *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984*, edited by P. D. Sheets and M. Mueller, pp. 187–192. Vínculos 10.
1986 *Settlement in the Cuenca de Arenal, Northwestern Costa Rica.* Unpublished Master's thesis, Department of Anthropology, University of Colorado, Boulder.
1992 *Prehistoric Adaptation to the Arenal Region, Northwestern Costa Rica.* Unpublished Ph.D. dissertation, Department of Anthropology, University of Colorado, Boulder.
Myers, T. 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, pp. 203–234. Mouton, The Hague.
Norr, L.
1986 Archaeological Site Survey and Burial Mound Excavations in the Río Naranjo/Bijagua Valley of the Guanacaste Cordillera. In *Prehistoric Settlement Patterns in Costa Rica*, edited by F. W. Lange and L. Norr, pp. 135–156. Journal of the Steward Anthropological Society 14. Department of Anthropology, University of Illinois, Urbana–Champaign.
Norweb, A.
1964 Ceramic Stratigraphy in Southwestern Nicaragua. *Proceedings of the 35th International Congress of Americanists* 1:551–561. Mexico City.
Odio O., E.
1991 La Pochota: Un complejo cerámico temprano en las tierras bajas del Guanacaste, Costa Rica. *Vínculos* 17:1–16.

Pearson, G. W., and M. Stuiver
1993 High-Precision Bidecadal Calibration of the Radiocarbon Time Scale, 500–2500 B.C. *Radiocarbon* 35:25–33.
Piperno, D. R.
1994 Phytolith Records from the Proyecto Prehistórico Arenal. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 286–292. University of Texas Press, Austin, in press.
Sheets, P. D.
1994 Chipped Stone Artifacts from the Cordillera de Tilarán. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 211–254. University of Texas Press, Austin, in press.
Sheets, P. D., H. F. Beaubein, M. Beaudry, A. Gerstle, B. McKee, C. D. Miller, H. Spetzler, and D. B. Tucker
1990 Household Archaeology at Cerén, El Salvador. *Ancient Mesoamerica* 1:81–90.
Sheets, P. D., J. Hoopes, W. Melson, B. McKee, T. Sever, M. Mueller, M. Chenault, and J. Bradley
1991 Prehistory and Volcanism in the Arenal Area, Costa Rica. *Journal of Field Archaeology* 18:445–465.
Sheets, P. D., and B. R. McKee (editors)
1994 *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica.* University of Texas Press, Austin, in press.
Sheets, P. D., and M. Mueller (editors)
1984 *Investigaciones arqueológicas en la Cordillera de Tilarán, Costa Rica, 1984.* Vínculos 10.
Sheets, P. D., and T. Sever
1988 High Tech Wizardry. *Archaeology* 41(6):28–35.
Snarskis, M. J.
1978 *The Archaeology of the Central Atlantic Watershed of Costa Rica.* Ph.D. dissertation, Columbia University, New York. University Microfilms, Ann Arbor.
1981 The Archaeology of Costa Rica. In *Between Continents/Between Seas: Precolumbian Art of Costa Rica*, pp. 15–84. Abrams, New York.
1984 Central America: The Lower Caribbean. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 195–232. University of New Mexico Press, Albuquerque.
Stone, D. Z., and C. Balser
1965 Incised Slate Discs from the Atlantic Watershed of Costa Rica. *American Antiquity* 30:310–329.
Stuiver, M., and B. Becker
1986 High-Precision Decadal Calibration of the Radiocarbon Time Scale, AD 1950–2500 BC. *Radiocarbon* 28:863–910.
Stuiver, M., and G. W. Pearson
1993 High-Precision Bidecadal Calibration of the Radiocarbon Time Scale, AD 1950–500 BC and 2500–6000 BC. *Radiocarbon* 35:1–23.
Stuiver, M., and H. A. Polach
1977 Discussion: Reporting of ^{14}C Data. *Radiocarbon* 19:355–363.
Stuiver, M., and P. J. Reimer
1993a Extended ^{14}C Data Base and Revised CALIB 3.0 ^{14}C Age Calibration Program. *Radiocarbon* 35:215–230.
1993b *CALIB User's Guide Rev 3.0.3.* Quaternary Research Center AK-60, University of Washington, Seattle.
Tosi, J.
1980 *Estudio ecológico integral de las zonas de afectación del Proyecto Arenal.* Centro Científico Tropical, San José, Costa Rica.
Willey, G. R., and C. R. McGimsey
1954 *The Monagrillo Culture of Panama.* Papers of the Peabody Museum of Archaeology and Ethnography Vol. 54. Harvard University, Cambridge, Massachusetts.
Winter, M. C.
1976 The Archaeological Household Cluster in the Valley of Oaxaca. In *The Early Mesoamerican Village*, edited by K. V. Flannery, pp. 25–30. Academic Press, New York.

NOTE

[1] Unless otherwise noted, all dates B.C./A.D. refer to a time scale in calendar years, rather than uncalibrated "radiocarbon" years. Dates B.P. refer to uncalibrated radiocarbon age.

Received March 11, 1993; accepted September 23, 1993