Prehistory and Volcanism in the Arenal Area, Costa Rica

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Multidisciplinary research conducted in the tropical rainforest of NW Costa Rica uncovered evidence of human occupation from Paleoindian and Archaic times through four sedentary phases to the Spanish Conquest. The village lifestyle, established by 2000 B.C., was remarkably stable and resilient in spite of the effects of at least nine prehistoric explosive eruptions of Arenal Volcano. Settlements maintained greater economic and political independence than Mesoamerican villages. Maize was cultivated by 2000 B.C., but it did not become a staple, as nondomesticated flora and fauna provided the bulk of the diet. A trend toward more elaborate funerary ritual, and toward greater distances between villages and cemeteries, occurred from 2000 B.C. to A.C. 1200. Optical (photographic) and digital remote sensing detected numerous linear anomalies, many of which have been confirmed as prehistoric footpaths that represent a system of human transportation and communication across the prehistoric landscape.

Introduction

The Proyecto Prehistorico Arenal conducted archaeological, botanical, and volcanological research from 1984 through 1987 in NW Costa Rica. The objectives of the project included establishing dated volcanic and cultural frameworks to study settlement, subsistence, and technology; exploring the effects of periodic explosive volcanism on regional societies; determining the adaptations to the tropical environment; and exploring the integration of local societies with, or isolation from, wider social and economic networks.

The Arenal area, along the eastern border of Guanacaste province (FIG. 1), was chosen for this multidisciplinary research project primarily because Arenal Volcano had erupted explosively at least nine times in prehistory (Melson and Saenz 1973; Melson 1984). The depositional sequence led to good preservation of sites and features under tephra (airfall volcanic ash, pumice, cinders) and provided a stratigraphic sequence of such deposits for dating purposes, independent of artifact analyses. Further, the Arenal area added to the comparative database for exploring the stability of human adaptations to tropical areas experiencing occasional major volcanic events. Similar research focusing on the effects of volcanic activity on more complex societies was initiated in El Salvador (Sheets 1983) but could not be continued because of civil war.

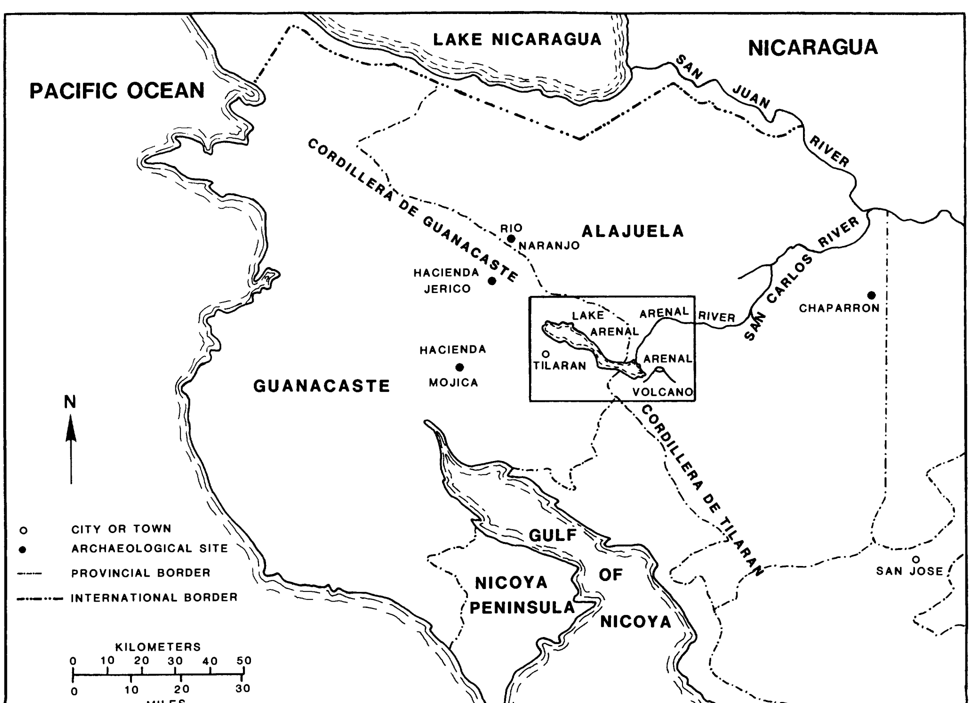
The objective of this article is to summarize the project's methods and results, and to explore the reasons why the developmental trajectories of societies to the south and north were so different from those in the Arenal area. More specifically, detailed comparisons can be made with volcanism and more complex societies in El Salvador and Panama.

Hazards research, involving natural and social scientists, explores the relationships between human societies and changing environments. All human societies possess adaptive mechanisms for coping with environmental fluctuations, yet there are limits to their ability to cope with changed circumstances in situ, and migrations or other radical responses may be necessary (Burton, Kates, and White 1978). It is difficult to compare responses to hazards by different human groups in prehistory, and the scale of the hazard plays a major role in determining the level of response. The effect of a volcanic eruption, of course, is dependent upon physical factors including magnitude, depth of burial of soils, chemistry, and grain size. Even the limited comparative framework in this paper suggests, however, that the human social variable has been neglected; simpler societies may have been better able to adjust to sudden, explosive volcanic events than were more complex societies. When Costa Rican volcanism and societies are compared to Salvadoran and Panamanian cases involving more complex societies, the simpler societies do appear to be more resilient in the aftermath of explosive eruptions. That may be because more complex societies have more concentrated populations, hierarchical political systems, are more dependent on an elaborate "built" environment, and have complex economic systems that include occupational specialization, redistribution, and long distance trade routes, all of which show grave effects when disrupted.

Guanacaste, the NW province of Costa Rica (FIG. 1), can be divided into three physiographic zones: the Pacific coast, the inland plains, and the mountains. The coast has been relatively well studied archaeologically, particularly by Lange (e.g., 1980), and settlement patterns and adaptations are better understood than those of the other two areas, at least from about 500 B.C. to the Spanish Conquest. Inland areas have not received as much attention, but certain projects have contributed significant adaptational and chronological information (e.g., Coe and Baudez 1961; Baudez 1967). Mountainous areas, locally called "La Cordillera," have been studied the least, with only a few preliminary publications resulting (e.g., Aguilar 1984).

The Arenal environment is tropical. There is a marked moisture gradient, with over 6000 mm (240 in) of mean annual precipitation in the wetter, eastern end of the research area near Arenal Volcano (FIG. 2), 3000 mm (120 in) along the continental divide in the central part of the area, and less than 2000 mm (80 in) in the Pacific drainage at the SW corner of the study area (FIG. 2). Seasonality of precipitation is minimal in the eastern end, but it is pro-

Figure 1. Map of NW Costa Rica, including modern towns and provinces, and archaeological sites mentioned in the text. Rectangle indicates area illustrated by Figure 2. Drawn by Brian McKee.



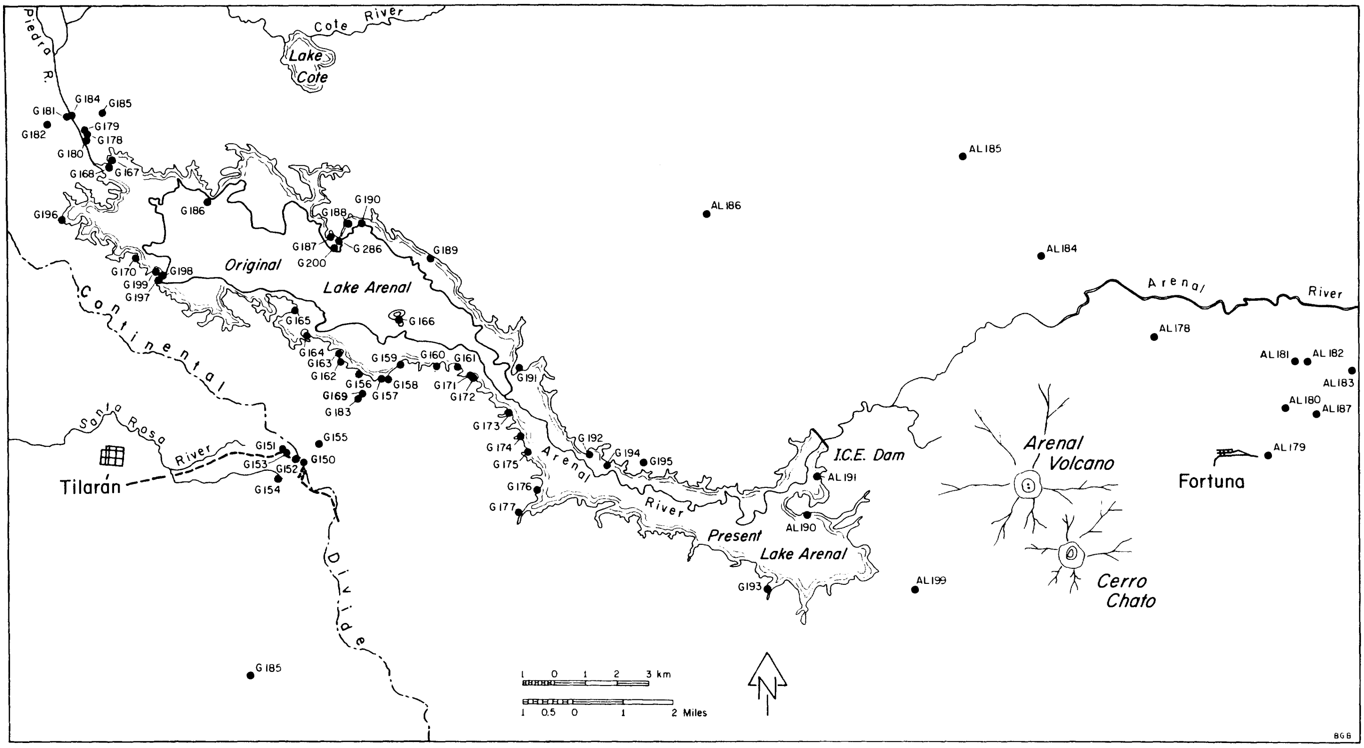


Figure 2. Map of the Proyecto Prehistorico Arenal research area, with archaeological sites in the province of Guanacaste marked with a G prefix, and those in Alajuela with an AL prefix. Note the I.C.E. dam, which has greatly expanded Lake Arenal since 1980. The dashed lines near Tilaran indicate Silencio Phase footpaths. Drawn by Barbara Bolton.

nounced in the western end, with wet (May-November) and dry (December-April) seasons. Soil saturation in the wetter area discourages agriculture, particularly of seed crops, but it becomes more feasible in drier areas. Most soils in the region were formed of weathered tephra, and generally are fertile and porous, although they are low in available phosphorus, potassium, zinc, and manganese (Tosi 1980). The soils not derived from recent tephras, either below or beyond them, are more typical of tropical soils, with high clay and aluminum-iron oxide content and relatively low fertility. Soil acidity follows the moisture gradient, with pH readings ranging from about 4 in the eastern end of the study area to about 6 in the western end. The wetter, eastern area receives markedly less solar radiation, due to greater cloud cover, resulting in lower mean temperatures. The eastern end averages only 4.4 hours of direct sunlight per day. The region is extremely windy, with a mean annual wind velocity along the lake of 23 km/hr; by comparison Chicago, the "Windy City" of the United States, averages 16 km/hr.

Of all terrestrial environments, tropical rainforests are known for maintaining the most stable climatic conditions (humidity, temperature) and having the highest standing biomass and species diversity (Richards 1966). Compared to other Costa Rican rainforests, the Arenal area is notable for a relatively rich flora and fauna (Tosi 1980). For instance, Tosi lists minimum species counts for the area as follows: 500 plants, 25 fish, 150 amphibians or reptiles, and 400 birds.

Research Methods

As with many areas in tropical Middle America, site visibility was very limited because of dense tropical vegetation and burial by tephra deposits. We wished to avoid the biased site-survey sample that would result from our finding only large cemeteries, the only kind of sites visible under the layers of tephra and vegetation (because of their large-scale stone construction), and from reliance on local informants. A means to detect sites of *all* types and sizes was needed. Traditional pedestrian survey of the Silencio area was found to be ineffective, even when augmented by posthole-digger probes or shovel tests. Geophysical instruments probably would not be effective because of irregular terrain and variable tephra depths, and because most sites are small and lack features detectable as geophysical anomalies.

Fortunately, the wave action of the recently-expanded Lake Arenal (the previous lake level was raised 30 m by construction of a dam in 1980) had gently removed most tephra along the shoreline, leaving artifacts and some features behind, independent of site size. Thus, the sampling universe is a meandering 10–50 m wide swath across the countryside, following the 540 m contour. A total of 39 sites was found, and numerous artifact scatters and isolated finds were encountered and recorded. Sizes ranged from small isolated finds (single artifacts to a few artifacts) to artifact scatters (less than 30 artifacts, generally ceramics) and small sites (30–100 artifacts) to large sites (over 100 artifacts in contiguous distribution). The operation-lot system was used in survey and excavation for field control (e.g., Sharer 1978).

The regional stratigraphy, consisting of tephra layers and soils developed on them, was carefully recorded at each site. Individual tephra layers often could be related to the known sequence of Arenal's eruptions (Melson 1984), and many of the eruptions had been radiocarbon-dated by previous research near the volcano. This provided a means of dating sites independent from ceramic or lithic analyses, where artifacts were found in situ between identifiable tephra layers. Major excavations were carried out at three sites, Tronadora Vieja, Bolivar, and Silencio, and extensive test excavations at four other sites. After the discovery that prehistoric footpaths could be detected in remote-sensing imagery, and confirmed by excavations and microstratigraphic analyses, 38 trenches were excavated in linear anomalies throughout the region.

The ceramic sequence for the Arenal area is based on the analysis of over 12,000 sherds, diagnostic as to vessel form and/or decoration, from surface collections and stratigraphic excavations (Hoopes 1984, 1987). Phase definitions derive from comparisons with existing sequences in Greater Nicoya (Baudez 1967; Sweeney 1975; Healy 1980; Lange et al. 1984), the Central Highlands (Aguilar 1976; Snarskis 1978), and the Atlantic Watershed regions (Snarskis 1978) of Costa Rica as well as broader comparisons with Mesoamerican types and interpretations of stratified contexts and associated radiocarbon chronology.

A total of 8755 chipped stone artifacts were collected and analyzed, with each classified into one of 18 typological categories, which were then compared to published collections in Costa Rica and other nearby countries. The ground stone collection was much smaller, with 224 artifacts collected from survey and excavations. Botanical remains, in the form of carbonized macrofossils as well as pollen and phytoliths, were analyzed for dietary and environmental information. Stable carbon isotopic analysis of human bone also contributed dietary information.

Research Results

The initial results of the 1984 field season were published in *Vinculos,* the journal of the Museo Nacional, San Jose, Costa Rica (Sheets and Mueller 1984). Both the database and the interpretations have been amplified considerably since then, as reflected by this article.

Volcanism

Arenal Volcano's 1968 eruption was the most violent one of historical times in Costa Rica, killing about 87 people and devastating mature tropical rainforest, along with some farms, ranches, and a small town. Activity has continued until the present, consisting of lava flows and occasional relatively small explosive eruptions (FIG. 3). Before the 1968 event, the volcano's eruptive history was unknown, but a flurry of research during the past two decades has revealed a series of 10 explosive eruptions during the past 4000 years (Melson 1984). The 1968 eruptive cycle provides a key to understanding the prehistoric eruptions. The first layer deposited was a coarse unit from the most violent component of the eruption, and it buried the soil and cultural materials that were on the surface. The coarse layer was overlain by fine tephra (airfall materials) deposited during the waning, less energetic phase of the eruption. Pedogenic processes operating during times of volcanic quiescence produced dark, organic-rich A horizons. Thus, in areas where the layers are preserved, the cycle of quiescence and violent explosive eruptions is evidenced by repeated sequences of soils buried by coarse and fine layers, with soils formed on top of the upper fine layers. A prevailing E-W wind direction is evident for the past few millennia. Tephra blankets throughout the sequence are thicker to the west of Arenal Volcano than in other directions.

The predecessor to Arenal Volcano was Cerro Chato (FIG. 2), and there are some indications that it experienced a final, paroxysmal eruption in approximately 4000 B.C. The eruption is not yet well dated, however, and its effects on the Archaic inhabitants of the region are unknown.

The earliest tephra layer to affect villages in the research area was designated Unit 61, and dates to about 1800 B.C. It apparently came from the first major explosive eruption of Arenal Volcano and, falling on the occupied countryside, assisted in preserving the structures and activity areas at sites such as Tronadora Vieja (G163; see sedentism section below).

The second tephra layer attributed to Arenal is our Unit 55, which fell about 800 B.C. It was from a major eruption, and the layer resulting from it is a relatively compact, hard surface in the Tilaran-Arenal area.

Two tephra layers, Units 53 and 52, fell at about the

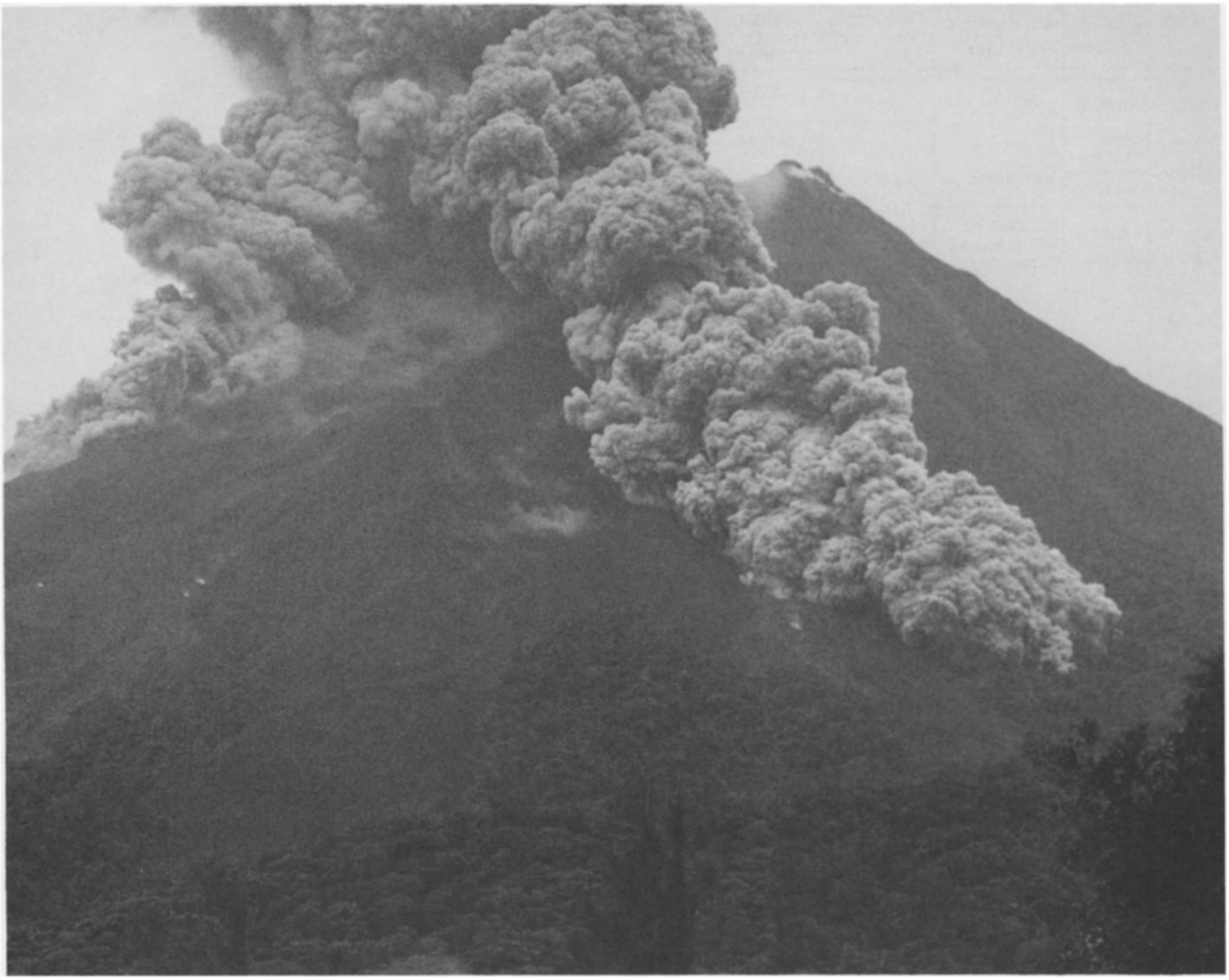


Figure 3. Arenal Volcano erupting on 13 July 1987. The eruptive column of an explosive eruption has collapsed into two pyroclastic flows moving rapidly downslope. This is a small eruption compared with the explosive one of 1968, which in turn was much smaller than the prehistoric explosive eruptions. Photograph by William Melson.

time of Christ. They were thinner than Units 61 or 55, and presumably they had lesser effects on the flora, fauna, and human settlements.

Subsequently, two relatively thick tephra layers fell in the area, the result of two major eruptions that were closely spaced in time. Designated Units 41 and 40, they appeared at about A.C. 800–900, and seem to have been sufficiently thick to have caused significant ecological disruption.

The last prehistoric eruption, one of the most violent, deposited Unit 20 in about A.C. 1500. Unit 20 is a very convenient and recognizable stratigraphic marker separating prehistoric and historical periods.

Melson (1984; Melson and Saenz 1973) has studied the tephra of each of the major 10 units at the type site of El Tajo, near the volcano, and many eruptions are radiocarbon dated. He has been able to correlate most of the Arenal project's archaeologically-associated tephra units with that master chronology, although some questions remain.

Phases of Occupation

Throughout all phases of the cultural sequence (FIG. 4), the Arenal area is characterized by striking continuities in settlement patterns, subsistence, and technology. Some basic elements of the technology were established by 4000

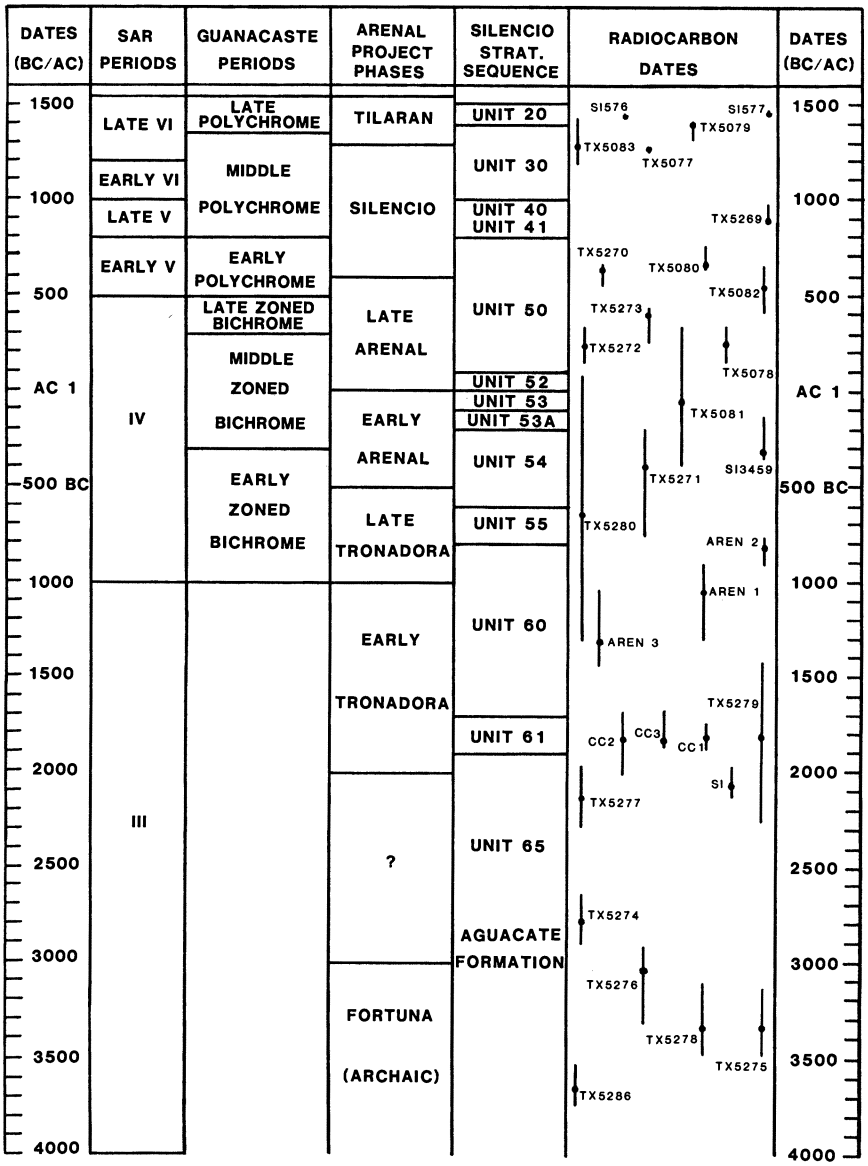


Figure 4. Chronological chart relating Arenal Project phases and the units of the Silencio stratigraphic sequence to corrected radiocarbon dates and other chronologies in the region. The SAR and Guanacaste Periods are from Lange and Stone (1984). Chart by Brian McKee.

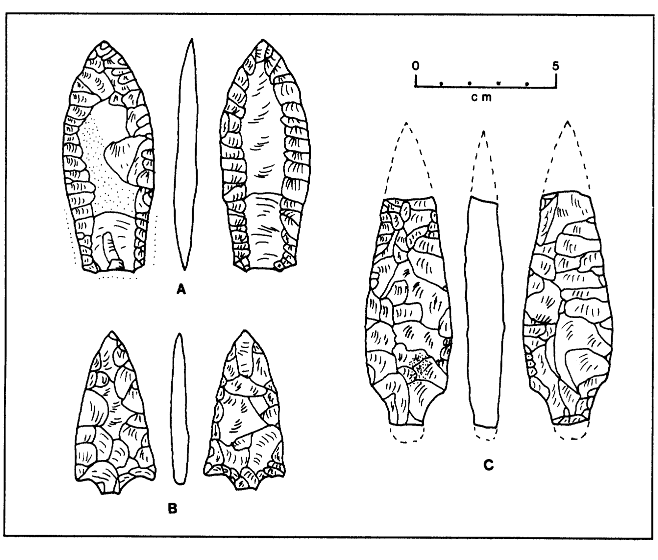
Villages were self-sufficent, no long distance trade

B.C. and remained essentially unchanged to the Spanish Conquest, including the primary means of generating cutting edges (core-flake technology) and the use of cooking stones. Most of the villages established in the two millennia before Christ were still occupied in the centuries preceding the Conquest. When compared to rates of change in ceramic and lithic technology at sites in Mesoamerica or the Andean area, Arenal artifacts changed very slowly. That conservatism is particularly pronounced in the chipped stone industry, which developed early into a simple and successful way of generating cutting and scraping edges, and changed little thereafter. In contrast to so many areas of Middle America, the Arenal area never experienced rapid or massive population increases or shifts into subsistence reliance on a single staple. Villages maintained high degrees of economic self-sufficiency, in contrast to their Mesoamerican counterparts which became dependent on more centralized economies and long-distance trade networks. Such stability is all the more remarkable in that it was maintained in spite of the ecological perturbations caused by at least nine explosive volcanic eruptions.

Throughout all phases, the favored locations for settlement were on relatively flat ground near the permanent streams that dissect the terrain. The densest concentration of villages was found along the south shore of the present Lake Arenal (recall that the previous lake level was raised 30 m by construction of a dam in 1980), against the foothills of the mountain massif, where people would have had access to a variety of ecological zones and resources. These include the shallow lake with its mammals and fish, the upper Rio Arenal valley with its fertile, volcanically-derived soils, and the ecological zones in the hills above them. The analyses of macrobotanical remains, pollen, and phytoliths indicate a mixed subsistence strategy including seed crops, tree crops, and probably some root crops and wild seeds, fruits, and berries.

The oldest artifact encountered during project research is a Clovis-like point (FIG. 5A), made of locally available chalcedony and found on the surface along the shore of Lake Arenal. It may date to ca. 10,000 B.C., if the dating of Clovis sites in the United States and Canada many thousands of miles to the north can be extended this far south. Although a surface find, it is evidence of the earliest known human occupation in the area. Along with the abundant Paleoindian artifacts from Turrialba in the wet highlands of the Atlantic watershed (Snarskis 1979), from the Madden Lake area, and from the dry Santa Maria area in the Pacific drainage of Panama (A. Ranere, personal communication 1989) it indicates that Paleoindian peoples successfully adapted to a range of habitats from drier plains to more humid forests. A Paleoindian phase was not formally defined for our project area since there were neither other artifacts nor excavated contexts clearly assignable to that time.

Figure 5. Bifacially flaked lithics: A) Clovis Point (G164-A1) found on Aguacate Formation along Lake Arenal shoreline; B) "Fortuna Point" from site G163, lot A1, surface, probably dating to the Archaic Period; C) "Silencio Point" from site G166, lot A2, probably dating to the Silencio Phase. This site is an island cemetery. Drawn by Payson Sheets.



The Fortuna Phase (4000–3000 B.C.) is known from surface finds, excavated debitage, and an excavated campsite, with calibrated radiocarbon dates ranging from approximately 3700 to 3000 B.C. A stemmed "Fortuna point" (FIG. 5B; cf. Sheets 1984a) was found, along with bifacial debitage from petrified wood, chalcedony, dacite, and other fine-grained, locally available materials. Cryptocrystalline materials were preferred over volcanic rocks. The waste flakes are thin, expanding, and show good flaking control. In contrast, the most common means of producing cutting edges was an informal core-flake percussion industry in which volcanic materials were preferred. The campsite, with its two hearths, yielded abundant stones that evidently were used for stone boiling, along with fragments of others that fractured as a result of rapid temperature changes.

A troublesome gap (FIG. 4) of 1000 years exists between the end of the Fortuna Phase and the beginning of the Tronadora Phase, as we have defined them. The best evidence for the transition exists at the Tronadora Vieja site (G163), where artifacts from both phases exist, along with considerable amounts of charcoal, but unfortunately the deposits are stratigraphically mixed. We were unable to find zones where artifacts of a single phase were associated with unmixed charcoal. The shift from a hunting and gathering lifestyle to occupation of sedentary villages with permanent structures, ceramics, and heavy ground stone implements apparently occurred between 3000 and 2000 B.C.

The earliest well-dated evidence of the Tronadora Phase (2000–500 B.C.) included houses and ceramics found at the Tronadora Vieja site (G163). Preservation of structures and activity areas was enhanced by burial under the Unit 61 tephra, probably deposited by the earliest eruption of Arenal Volcano at about 1800 B.C. Ceramics were very well made and elaborately decorated by incising and painting (Hoopes 1984, 1985, 1987). Burials, probably secondary, evidently were in small rectangular pits between houses in the village, occasionally accompanied by pottery. Ground stone implements were rare. Metates were oval with short-knob tripod legs, but no manos were found. Structures are circular in plan, with poles supporting presumably thatched roofs over floors of tamped earth.

Tronadora Phase pottery from Tronadora Vieja is the earliest-dated ceramic assemblage in Costa Rica (FIGS. 6, 7), and radiocarbon dates indicate that it first appeared in

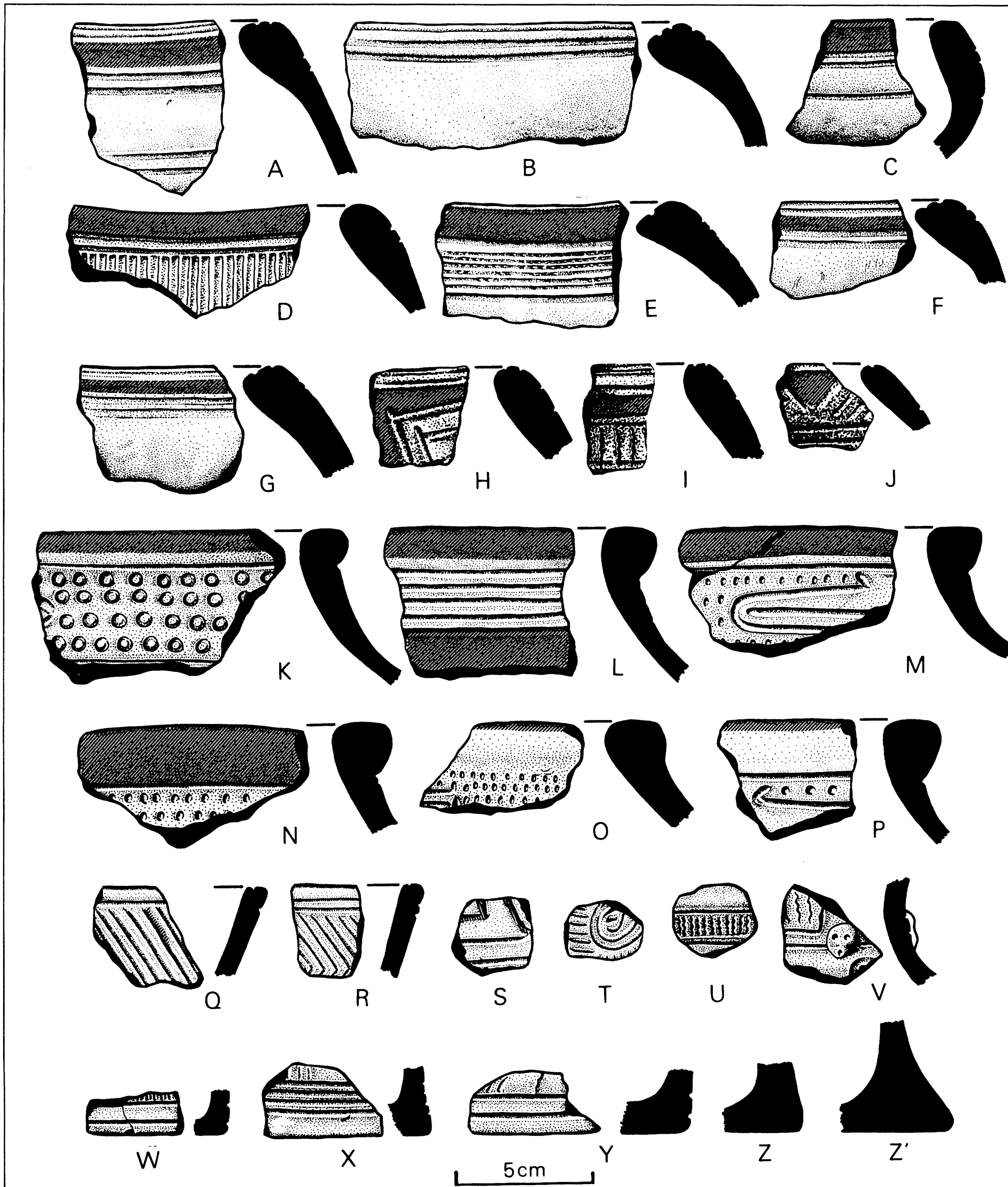


Figure 6. Representative sherds of the Tronadora Phase. All are from the site of Tronadora Vieja (G163). A-J: Tronadora Incised neckless bowls and jars; K-P: squat, necked jars (K, reed punctation; L, groove-incision; M-P: Tigra Grooved-punctate); Q-T: Atlantic Red-filled Black group; U: shell-stamped; V: shell-stamped with pellet appliqué; W-Y: grooved cylinders; Z-Z[1]: bases from Zetillal Shell-stamped vessels. Drawn by John Hoopes.

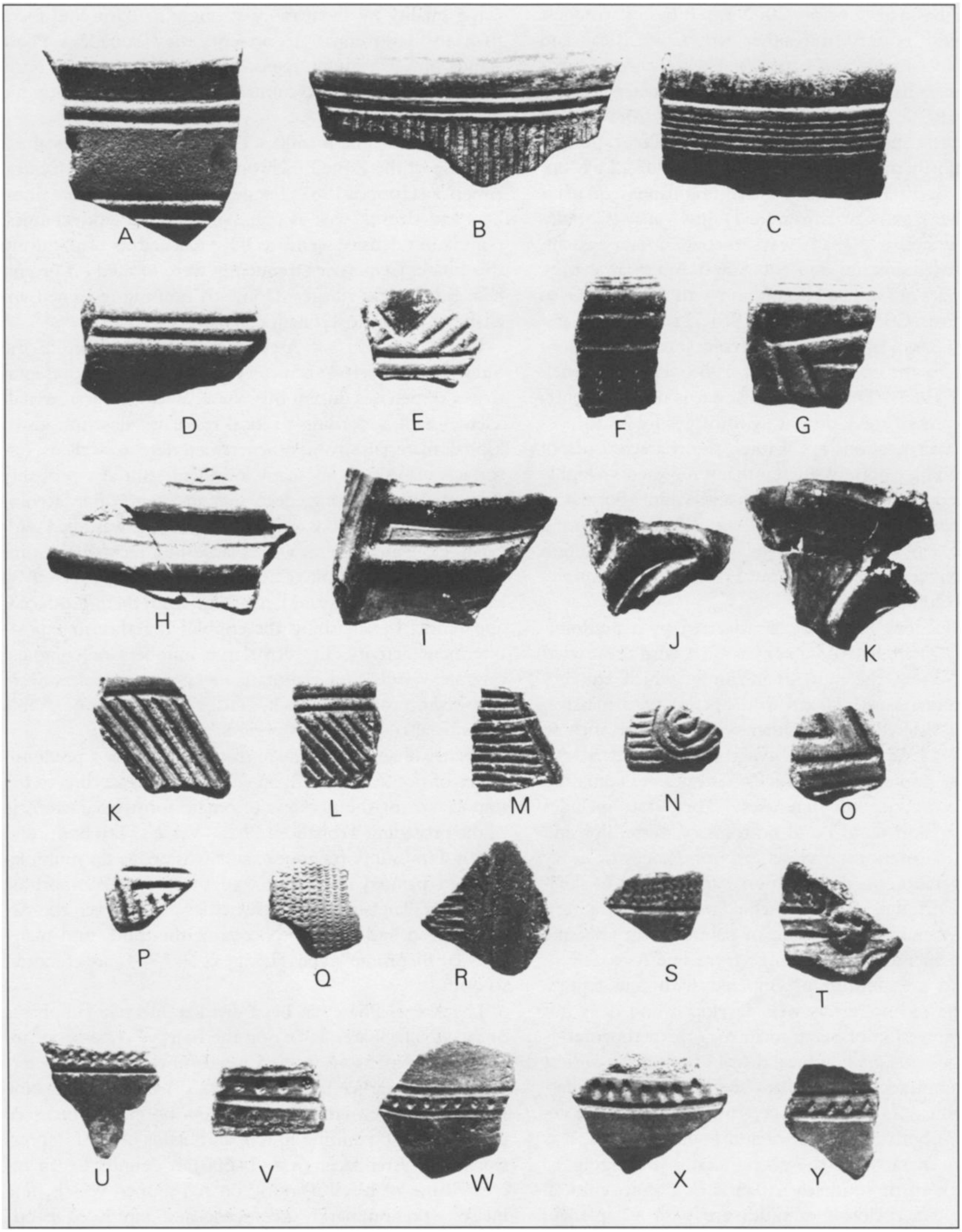


Figure 7. Sherds of the Tronadora Phase from the site of Tronadora Vieja (G163). Descriptions: A-G: Tronadora Incised; H-K: Tajo Gouge-incised; K^1-P: Atlantic Red-filled Black group; Q-R: Zetillal Shell-stamped with shell-edge rocker-stamping; S and U: shell-stamped; T: shell-stamped with pellet appliqué; V-Y: Tigra Grooved-punctate. Photographs by Francine Mandel Sheets and John Hoopes.

the Arenal basin at or before 2000 B.C. It has its strongest affinities with pottery from other early Costa Rican and Nicaraguan complexes: Chaparron from the San Carlos region (Snarskis 1978), Dinarte from Ometepe Island (Haberland 1966, 1982–1983), Loma B from coastal Guanacaste (Lange 1980), early Naranjo Phase pottery from the northern cordillera (Norr 1982–1983), La Montana and Barva from the Central Highlands (Snarskis 1978, 1984a), and Curre from the Diquis Valley (Corrales 1985). It is similar in many ways to contemporary assemblages in Mesoamerica and NW South America, sharing certain modes of form and decoration with Barra and Ocos to the north (Coe and Baudez 1961; Lowe 1975) and Canapote, Barlovento, and other complexes of northern Colombia to the south (Bischoff 1966, 1972; Reichel-Dolmatoff 1985). Tronadora, however, is not sufficiently similar to any of these distant assemblages for us to postulate a direct relationship. Rather, the characteristics of Tronadora Phase pottery suggest that it represents a highly regionalized manifestation of Early and Middle Formative ceramic technology even within Costa Rica, representing just one facet of what was probably a widespread tradition of decorated ceramics throughout Lower Central America as early as 2000 B.C.

The Tronadora Phase is characterized by a predominance of tecomate-like (bowl- or jar-form, with a restricted opening) vessels, the most abundant of which are very large (as much as 40–50 cm in diameter) with massive, exteriorly-bolstered rims. Other vessel forms include squat, necked jars and tall, hyperboloid cylinders. Although red-painted rims and incised zones are common, plastic decoration predominates. This last includes grooved incision with round bottoms on vessel lips and horizontal decoration on vessel exteriors, zones of heavy round punctation, reed punctation, various types of shell-stamping (including zig-zag, shell-edge rocker-stamping), and an exuberant combination of painted strip appliqué and gouge incision. Pastes range from fine to coarse in texture and are uniformly tempered with fine tephra. Overall, the technology is well developed and does not give the impression of being incipient or experimental.

Given the wide geographical distribution of the earliest ceramic complexes in Costa Rica and the general similarities of Tronadora Phase pottery to Early Formative ceramics from both Mesoamerica and South America, it is difficult to characterize these ceramics as belonging to either northern or southern, Atlantic or Pacific, cultural traditions. Their closest affinities are with Chaparron, from the northern Atlantic watershed (Snarskis 1978), and Dinarte, from Ometepe Island in Lake Nicaragua (Haberland 1966), and characteristics of surface finish and firing quality tie them more strongly to Barra and Ocos than to Barlovento. At present, the Tronadora Phase stands out as a highly regionalized complex in the Early and Middle Formative cultural landscape of the Intermediate Area.

The Arenal Phase (500 B.C.-A.C. 600) is the local expression of the Zoned Bichrome horizon in lower Central America (Hoopes 1987; Lange 1984). Based on site numbers and sizes as well as regional abundance of ceramics, population density seems to have reached its peak during this phase. Cemeteries frequently were located on prominent ridges near villages. Domestic housing remained unchanged from the Tronadora Phase.

Our excavations of Arenal Phase burials were at the Sitio Bolivar (G164) cemetery; it evidently is representative of cemeteries during this phase, at least for the Arenal-Tilaran area, according to local residents' descriptions of looted materials from other cemeteries, as well as our surface inspection of many of them. Burials, probably primary, were in long, deep pits and were often accompanied by grave goods. After the burial pit was filled with earth, elongated stones were placed in a rectangle outlining the subsurface pit. The cemetery area is covered by broken river cobbles and large flakes from them produced, apparently, by smashing the cobbles together in a post-interment activity. In turn, large numbers of complete ceramic vessels and elaborate metates and manos were smashed on top of the rocks (FIG. 8). A number of cobble mounds also date to this period.

Arenal Phase ceramics are distinguished by a predominance of necked jars with an accompanying decline in the importance of the neckless tecomate forms characteristic of the preceding Tronadora Phase. Vessels with both solid and hollow supports appear at this time, as do multiple-brushed painted decoration and the use of zoomorphic appliqués. The strongest stylistic ties are between the Arenal region and Greater Nicoya at this time, and many "Zoned Bichrome" types (Lange et al. 1984) are common to both.

The Arenal Phase has been divided into two subphases or facets (cf. Sharer 1978) on the basis of cross-sequence ceramic comparisons and radiocarbon dating. Characteristics of the earlier facet (500–1 B.C.) include bichrome painting (red-on-cream) delineated by heavy incision, multiple-brush painting in red, and bands of shell impressions. The later facet (A.C. 1–600) is defined by an increased use of black painting on red-slipped vessels, fine incised (predominantly geometric and interlaced band) decorations, resist decoration, and—at the end of the facet—the appearance of early polychromes. Although the overall character of the Arenal Phase ceramic assemblage

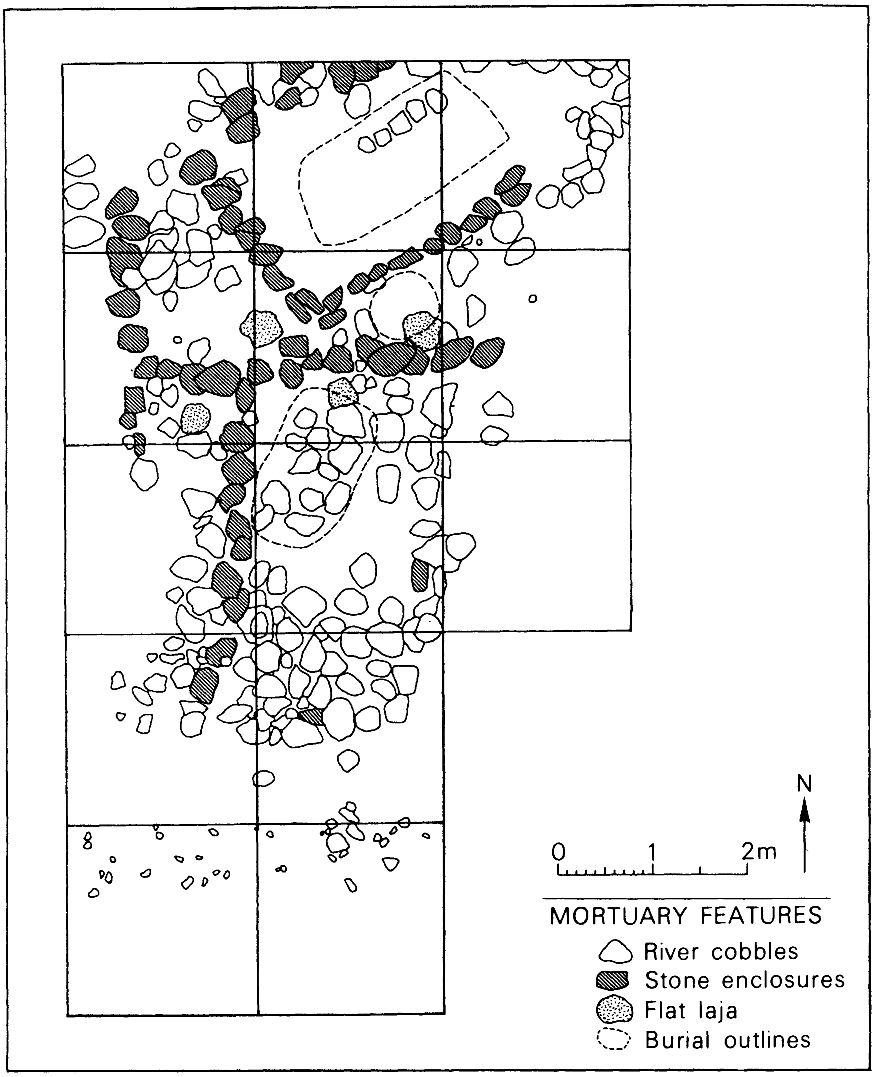


Figure 8. Operation E in the Sitio Bolivar cemetery (G164) dating to the Arenal Phase. Note the outlines of the burial pits; after burial the grave was marked by elongated rocks forming stone enclosures, which were filled in by smashing large river cobbles into place. The rock layer was capped by broken, elaborate metates and decorated ceramic vessels. Laja is flat, exfoliated volcanic rock; in this area, usually andesite. Drawn by John Hoopes.

is most similar to that of Greater Nicoya, ties to the Atlantic watershed are evident throughout the phases from the use of red-on-cream decoration, zoomorphic appliqué, and elaborate, hollow supports. In addition to these similarities, trade ceramics from the Atlantic watershed appear at the Bolivar site (G164) and elsewhere in eastern Guanacaste (Ryder 1982–1983a) ca. A.C. 300–600.

Ground stone artifacts became much more common in the Arenal Phase, and were used for utilitarian and religious or status purposes. Metates had ovoid grinding surfaces, and virtually all had three cylindrical or conical legs. "Bar manos," long and cylindrical in shape with the end often overhanging the grinding surface of the metate, were common. Celts, with sides that were straight or flared to a wide bit, were plentiful and commonly buried with the deceased.

Digital and optical remotely-sensed data provided by NASA aided in our understanding of the Arenal Phase. These included satellite-based Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) imagery, as well as aircraft-based color infrared and true color photography, and imagery from synthetic aperture radar, Thermal Infrared Multispectral Scanner (TIMS), and laser profiler (Lidar). In addition, the Costa Rican Instituto Geografico the footpaths

provided numerous black and white aerial photographs.

Numerous linear anomalies were found in the imagery, and the excavation of trenches across these features revealed that many were prehistoric footpaths. It was possible to confirm features as footpaths through their topographic positions, their morphology, disturbances in the volcanic strata of the region, associated artifacts, and their association with archaeological sites. Footpaths were dated utilizing the stratigraphy, associated artifacts, and the dates of the sites at their termini. For a more detailed discussion of the formation processes involved in the generation of these paths, the reader is directed to Sheets and Sever (1988).

The majority of the footpaths encountered dated to the Silencio Phase (see below), but one path dating to the Arenal Phase was discovered. This path, located to the west of Lake Arenal, linked a cemetery (G180) with a habitation site (G184). The path crossed directly over the top of a hill located between the sites. Along the sides of the path, near the top of the hill, we found a large concentration of river cobbles and potsherds. The cobbles had been carried to the top of the ridge and placed on the ground on either side of the footpaths. Numerous potsherds as well as several broken but nearly complete pots were found scattered over and among these rocks. A pot-smashing ritual similar to that noted at the Bolivar site may be indicated. Snarskis (1981) has interpreted smashed tripods found at Atlantic watershed cemeteries as the remnants of *chicadas* (rowdy, drunken feasts), and these broken pots may be related to similar rituals.

The Silencio Phase (A.C. 600–1300) was characterized by a population decline, with a decrease in the number and size of sites around Lake Arenal. Polychrome pottery appeared in the area, but lithic industries were little changed. Bifacial flaking of projectile points/knives, possibly suspended during the Arenal and most of the Tronadora phases, returned with the advent of the "Silencio Point" (FIG. 5C). Bifacial flaking of celt blanks continued uninterrupted from the Tronadora through the Tilaran phase, however.

Burials were encased in stone cist tombs (slab boxes of flat-fracturing volcanic stone locally called *laja*) and were accompanied regularly by grave goods (FIG. 9). Construction techniques are virtually identical to those of stone cist tombs in the central highlands of Costa Rica (Snarskis 1984a). Silencio tombs often included miniature polychrome vessels, gold pendants, and elaborate metates, and cemeteries frequently were farther from villages than in previous phases, many kilometers in the case of the Silencio cemetery (G150). The Silencio Phase is the culmination of the trend, which began during the Tronadora and Arenal Phases, toward increasing distance between settlements and their cemeteries, and increasing complexity in tomb construction and burial furniture. Direct evidence of the separation between cemetery and habitation sites is provided by the footpaths found through remote sensing (see below).

The ceramic evidence for strong contacts with Greater Nicoya cultures, first noted in the Tronadora Phase, continues into the Silencio Phase (A.C. 600–1300). Throughout Greater Nicoya, there was a proliferation of elaborate, high-quality polychrome ceramic types during this period, a trend also evident in the Cordillera. Polychrome ceramics were found in abundance at the Silencio site (G150), primarily cached in stone-cist burials (Bradley 1984). Small polychrome vessels, which may have been manufactured in the Tempisque Valley to the west, were used as burial offerings, in one case in association with a gold pendant. A large number of sherds from the Silencio site can be identified as Middle Polychrome Period types from Greater Nicoya, and may represent items acquired from regions to the west through trade or exchange. The most common polychrome type is one of local manufacture, however. It is technically not as well made as the imported vessels, and stylistic similarities indicate local imitation of Nicoya originals.

The Silencio Phase is also characterized by an abundance of incised ceramics, a continuation of a very long-lived tradition in the area. Decoration in fine line motifs, which often extend to the upper surfaces of flat vessel rims, include geometric, hachured frieze, and guilloche patterns, occasionally infilled with white pigment. Vessel forms include a variety of jars and open bowls with a T-shaped rim profile which is repeated in polychrome, bichrome (red-on-cream), and incised monochrome types.

Silencio Phase metates have more blocky, rectangular forms with shorter and thicker legs and more elaborate surface decoration than in previous phases. Zoomorphic and abstract motifs are common on metate edges and legs, and often cover part of the grinding surface. Most metates have three legs. Manos are virtually unchanged from the previous phase. Celts, formerly with straight bits, have convex ones; and celts with flaring sides continue.

The remote sensing and field verification that detected one footpath dating to the Arenal Phase encountered numerous Silencio Phase paths that linked cemeteries with habitation sites and with natural resources (springs, sources of laja used in tomb construction, Lake Arenal, and various rivers and other drainages).

The detection of linear anomalies in the remotely sensed data and the confirmation of many as prehistoric footpaths are beginning to establish the network of human trans-

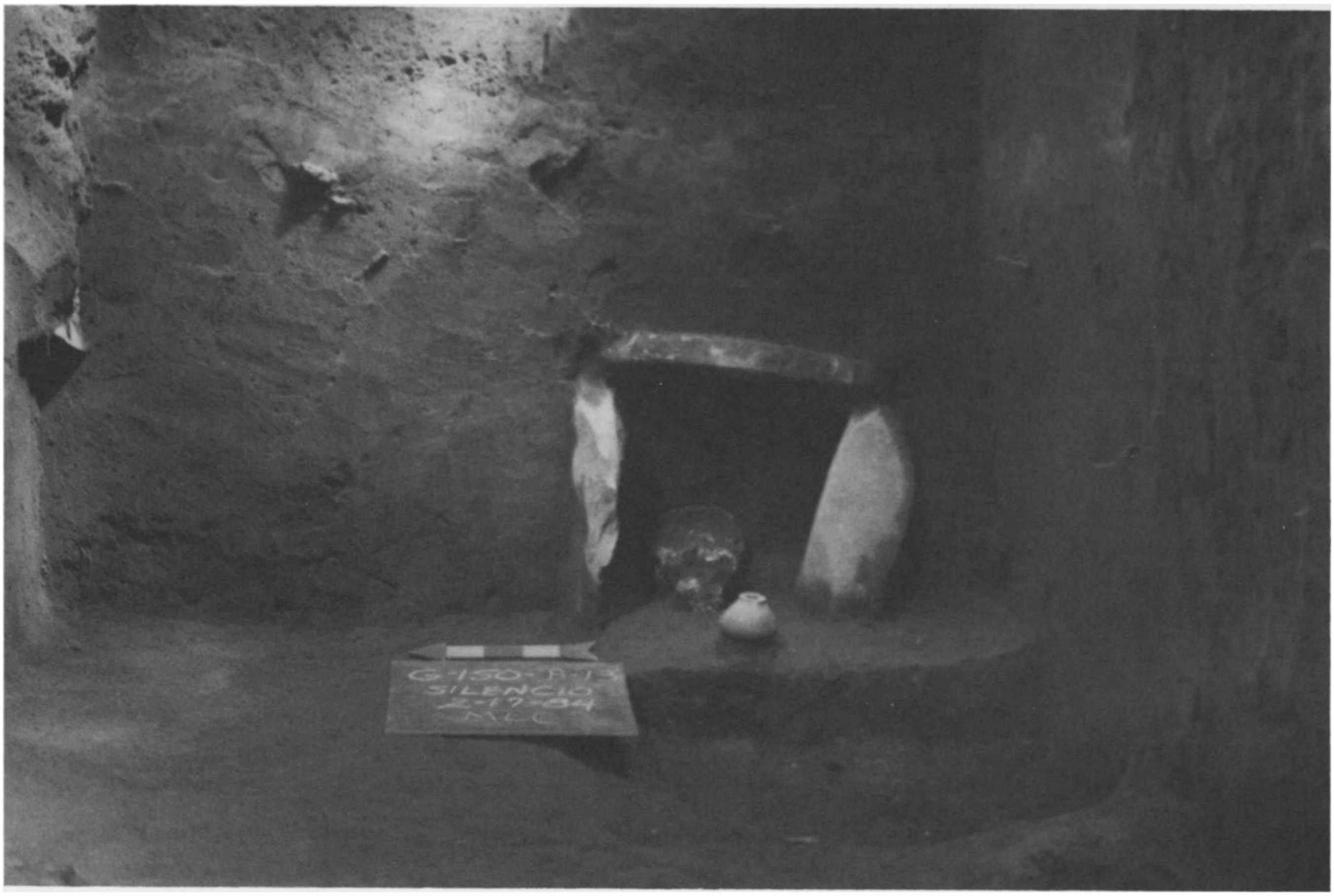


Figure 9. Stone cist burial, Silencio Cemetery, site G150 (lot B15). The laja was used to create a box around the skeleton; a miniature Cabuyal Polychrome vessel is visible in front of the face. The volcanic ash of Unit 40, which fell about A.C. 900, is the whitish level above the top of the stone cist. Arrow (25 cm) points north. Photograph by Mark Chenault.

look up Posey (1983)

portation and communication across the landscape (Sheets and Sever 1988). The prehistoric path network is much like the contemporary one recorded by Posey (1983), for the Kayapo Indians in the Amazon drainage of Brazil, which links villages, fields, and resources.

In the Tilaran Phase (A.C. 1300–1500), the population continued to decline, as evidenced by still-smaller site size. Cultural affiliation with the Greater Nicoya subarea weakened in this phase, while apparently increasing with respect to the Central Highlands and Atlantic Watershed regions. The change in ceramics away from Greater Nicoya types is similar to a stylistic change in the same direction noted by Creamer (1983) on the islands in the Gulf of Nicoya. Previous phases showed only weak connections toward the east and SE, as Cordilleran peoples maintained primary cultural affiliations with Greater Nicoya to the west. In contrast to the settlement pattern of scattered small-to-medium-sized villages in the previous phases, the Tilaran Phase is characterized by many small hamlets widely dispersed across the countryside. The settlement pattern is more like that of the Tronadora Phase than any other. Because we found no burials dating to this phase, it is not known if the trend toward more elaborate funerary practices, evident in the previous three phases, continued.

Tilaran Phase pottery shows much less decorative variety than in the preceding phases. One striking characteristic is that there appears to have been an almost complete break with the rich polychrome traditions that continued to flourish in Greater Nicoya at this time. Ceramics are characterized by unslipped monochromes, occasionally decorated with zoomorphic appliqué on handles and supports. The quality of these ceramics in terms of texture and firing is uniformly poor.

Curiously, no ground stone artifacts dating to this phase were found. This may reflect a decline in the need for such implements, and thus in the frequency of their manufacture, but it should be mentioned that there were few excavations or surface collections at purely Tilaran Phase sites. The paucity of ground stone artifacts could be real, or could be the result of sampling.

The Arenal research area straddles the border between the Greater Nicoya archaeological subarea to the west and the Atlantic Watershed to the east (Lange 1984: fig. 7.1). An assessment of the cultural materials recovered by the Arenal project permits a close examination of the nature of that border through time. During all phases, stylistic and technological characteristics of both areas have been found in the Arenal area. The Tronadora Phase shares characteristics with La Montana and Chaparron in the Atlantic watershed; comparisons with Guanacaste to the west are difficult because of the lack of contemporaneous sites, but during the Arenal and Silencio Phases (FIG. 4) the Arenal area shared more material culture with Greater Nicoya than with the Atlantic region. That relationship, however, was not maintained during the Tilaran Phase. We believe that a Cordilleran subarea can be defined between Greater Nicoya and the Atlantic areas (Sheets 1984b). Its geographic extent is unknown, but it probably included the chain of volcanos and hills from Orosi Volcano in the north to Monteverde and perhaps Cerro Cedral in the south. It would include the Rio Naranjo-Bijagua Valley (Norr 1982–1983) and the Hacienda Jerico (Finch 1982–1983). If this is true, the Arenal sites and others in the Cordilleran subarea were not merely a peripheral derivative of another cultural tradition, or a blend of two traditions, but a relatively independent one, only occasionally accepting and incorporating outside innovations.

Early Emergence of Sedentism

During the survey of the present lakeshore in 1984, Tronadora Phase ceramics were encountered at scattered localities, usually as minor components of sites dominated by Arenal or later ceramics. Since the Tronadora Vieja site (G163) had a predominance of those early ceramics, it was excavated in 1985. This is the earliest Formative village yet excavated in Costa Rica. Architecture and other features, maize horticulture, and elaborate ceramics are dated securely to about 2000 B.C., and possibly as much as a millennium earlier. Some Archaic artifacts were found in the clay-laden, reddish tropical soil capping the Aguacate Formation, which was present prior to Arenal's eruptions that deposited tephra across the countryside. The artifacts include the stemmed "Fortuna Point" and some bifacial debitage, likely associated with the 4th-millennium B.C. radiocarbon dates from the Aguacate Formation. We were not able to separate the late Archaic artifacts and charcoal from the early Tronadora Phase materials stratigraphically, so we do not know where within the 3000–2000 B.C. time span the Archaic/Formative boundary should be drawn.

The explosive eruption that deposited Unit 61 at the Tronadora Vieja site shortly after 2000 B.C. helped preserve at least five houses with associated ceramics, lithics, and activity areas. Houses had circular ground plans 5–8 m in diameter and were built with poles supporting roofs that presumably were thatched (FIG. 10). The doorways faced eastward and downslope toward the lake. Internal posthole patterns suggest room dividers or elevated platforms for domestic activities. Smaller postmolds outside the houses may have belonged to storage facilities or other small structures. Field testing for inorganic phosphates (Eidt 1984) assisted in identifying habitation areas.

Floors in the early Tronadora Phase houses were of simple tamped earth, and few artifacts were found on them. Some manufacture of bifacial implements took place in or near the houses, and cooking stones were used to boil water, a holdover from the Archaic. The assumption that this kind of cooking was replaced by that in ceramic vessels is unwarranted in the Arenal area, as the two methods coexisted for at least 3500 years until the Spanish Conquest. Caches of cooking stones were found, along with discarded, fractured ones, outside the house walls. Sedentism was based more on exploitation of the rich and diverse flora and fauna of the natural tropical rainforest than on domesticated staple foods.

Previously, the earliest known circular houseplan in Costa Rica was at La Fabrica near San Jose, dating to A.C. 500–900 (Snarskis 1981: 58, 1984a: 221). Rectangular houses appeared earlier than La Fabrica, for example at Severo Ledesma in the eastern lowlands between A.C. 1 and 500. Contemporary houses in Mesoamerica also had rectangular floor plans, leading Snarskis (1984b) to suggest that Costa Rican house types were derived from Mesoamerica. The very early circular houses found at Tronadora Vieja indicate that this was not the case, at least in the Arenal area. These houses predate rectangular houses from Mesoamerica, indicating that they are either a local development or derive from antecedents to the SE.

Subsistence

Maize was found in deposits of all sedentary phases, from the Tronadora through the Tilaran, in carbonized kernel, pollen, or phytolith form. Grinding stones (i.e., manos and metates) also occurred in all phases following the Archaic (Chenault 1984). From these qualitative indicators one might conclude that much maize was culti-

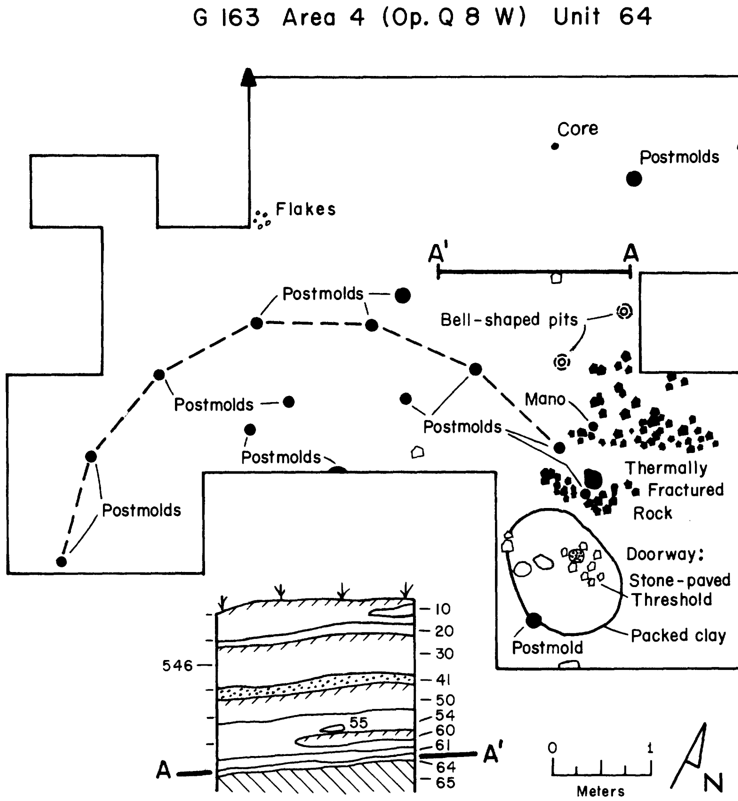


Figure 10. House 1, Tronadora Vieja site (G163). The house, almost 6 m in diameter, was buried by the volcanic ash (Unit 61) from Arenal Volcano's earliest eruption, about 1800 B.C. The position of the house floor and surface of outside activity areas are indicated by the A-A[1] line in the stratigraphic diagram. Drawn by John Bradley.

vated, processed, and consumed, and even that it was the staple. But maize, because of its hard shell, characteristic phytoliths, and abundant pollen—and the fact that it is more often parched or roasted and thus more frequently carbonized than are other foods—has a higher probability of being preserved and thus easily overemphasized in subsistence reconstructions. For example, Coe and Baudez (1961) infer "intensive maize agriculture" for the Zoned Bichrome Period in NW Costa Rica, in spite of a weaker database for maize cultivation than that of the Arenal Project. The frequency of manos and metates (or their ratios to sites, to ceramic artifacts, and to lithic artifacts) in the Arenal area, however, is far less than in SE Mesoamerica, as exemplified at Chalchuapa (Sharer 1978), Barton Ramie (Willey et al. 1965), and the Zapotitan Valley (Sheets 1983). The heavy use wear on most SE Mesoamerican metates contrasts with the relatively light usewear on most specimens from the Arenal area.

The ratio of the stable carbon isotopes, $^{13}C/^{12}C$, in human bones can be a dietary indicator (Van der Merwe 1982; Friedman and Gleason 1984). The probability of marine food sources contributing ^{13}C isotopes and therefore inflating the ratio is low in the Arenal area. Most vegetative food sources in the Cordillera use a 3-carbon photosynthetic pathway, and discriminate against the heavier ^{13}C isotope. Maize has a 4-carbon pathway, and probably was the principal source of the ^{13}C isotope in the prehistoric diet. Our interpretation of the isotopic analyses of human bone from G150 is that less than 12% of the diet, at least in the Silencio Phase, was from C-4 plants such as maize. Thus, while we believe the qualitative and quantitative subsistence evidence illustrates the utilization of maize from the Tronadora Phase to the Conquest, it appears that other species made up the bulk of the diet.

The maintenance of a broad-based subsistence strategy may have contributed to an adaptational stability greater than that achieved in Mesoamerica. Many modern groups, including the Kuna of Panama and various Talamancan tribes, do not rely on staples but maintain broad subsistence bases (Taylor 1989; Johnson 1948), in spite of the availability of plants such as maize and beans which can be used as staples (Taylor 1989: 277; Johnson 1948). As population increases, maize and beans can be planted and tended with increased labor investment to produce more per unit area, but this may lead to, or be subject to, hazards including increased soil weathering, erosion, leaching, drought, or pestilence. In contrast, reliance on diverse wild and cultivated species and maintenance of populations at lower densities allows for demographic and adaptational stability. Harris (1973) has argued that seed crop agriculture tends to be less stable than root-crop or vegeculture because of its tendency to cause environmental degradation.

Although Arenal area metates probably were used to grind maize, and likely some other materials, they also may have had a major symbolic function. That interpretation is strengthened by the fact that these artifacts are more elaborately decorated than their domestic counterparts in Mesoamerica. Lange (1971: 212–217) noted the paucity of use wear on legged, decorated metates from the Rio Sapoa area of extreme NW Costa Rica, and argued that they were used more symbolically, as "seats of power" or symbols of office. In contrast, Snarskis (1984a: 210) argued for regular domestic use of most Costa Rican metates. Our data indicate that both interpretations probably apply to Arenal area metates, but the relative importance of utilitarian versus symbolic uses is difficult to assess accurately. In general, metate decoration does increase from the Tronadora and Arenal Phases, to culminate in the Silencio Phase, yet grinding use wear per metate decreases over the same time span, perhaps indicating that symbolic uses were increasing in importance faster than utilitarian uses.

Economics

Settlements in the Arenal area had a greater degree of economic self-sufficiency than their SE Mesoamerican contemporaries, as exemplified by Chalchuapa (Sharer 1978) and by settlements of all sizes in the Zapotitan Valley (Sheets 1983). Arenal residents evidently were able to obtain food, materials for housing, raw materials for the manufacture of chipped and ground stone implements, cooking stones, clay and temper for pottery, pigments, and other supplies from the environs of their settlements, without having to depend on elaborate procurement networks, as in Mesoamerica. Production of cutting edges by simple percussion technology was performed in each household. The only common utilitarian items made of material from outside the area were celts; the metamorphic rocks, primarily a plagioclase-phyric andesite with some hydrothermal alteration, came from an outcrop in lowland Guanacaste from 40 to 60 km to the west. This could have been obtained by down-the-line trade or by direct procurement. Some goods, more in the symbolic/ritual domain, came from moderate distances; these include various polychrome vessel types (Hoopes 1984) and gold pendants (Chenault and Mueller 1984) in Silencio Phase tombs. The ceramics apparently came from western Guanacaste, and gold pendants may have come from the Atlantic lowlands to the east, judging by stylistic similarities to those found there. Gold occurs naturally in the mountains and along the Pacific slope, however. Both ceramics and gold pendants could have been obtained by informal trade, gift exchange, or direct procurement. If the latter, the search for symbols of power in distant localities by nascent chiefs might have been the reason for their procurement (Helms 1979). Mesoamerican communities, such as those in the Zapotitan Valley (Sheets 1983), were more dependent on long-distance trade routes for materials such as obsidian, vesicular basalt, metamorphic rocks, and perishable goods. Mesoamerican economic and political systems functioned on the basis of social differentiation, occupational specialization, centralization of authority, and controlled redistribution; therefore sites are characterized by diversity and interrelatedness instead of the repetition of self-sufficient units of production and consumption observed in the Arenal region.

Summary and Conclusions

The Proyecto Prehistorico Arenal was designed to study settlement and subsistence in the Costa Rican tropical rain forest subject to the occasional disturbance caused by an explosive volcanic eruption. It was hoped that sites could be found with occupations spanning at least a millennium, and perhaps two millennia of prehistory, in order to explore the resiliency of relatively simple societies in Costa Rica that were exposed to explosive volcanism, and to compare it with that of more complex societies in El Salvador and elsewhere that were also affected by sudden eruptions. The Arenal database developed by us for exploring settlement, subsistence, and volcanism is more extensive geographically and chronologically than originally anticipated, ranging from the very wet Atlantic drainage to the dryer monsoon climate on the Pacific drainage, and including evidence of Paleoindian and Archaic occupation prior to the emergence of sedentary village life by 2000 B.C.

Arenal Volcano caused periodic stresses on the flora, fauna, and societies living nearby during the past 4000 years. Those stresses decline with distance from the source, being negligible at distances of more than 20 to 30 km. The volcano has erupted at least eight times between its first at about 1800 B.C. and its most recent in 1968, providing a series of time-stratigraphic horizon markers throughout much of the area.

Five phases have been defined for the Arenal area, from the Fortuna Phase (the local Archaic) through the Tilaran Phase just prior to the Spanish Conquest. It is significant that the degree of culture change represented by the phase boundaries is markedly less than in southern Mesoamerica. The degree of continuity in settlement patterns, in basic technology, in artifact style and form, and in subsistence is striking. The success of the inhabitants in establishing village life by 2000 B.C., with a basic technology of stone boiling and core-flake technology for production of cutting edges, which derived from the Archaic, is impressive. A part of that success probably is based on a high degree of village self-sufficiency, maintained until the Spanish Conquest. Subsistence stability probably was facilitated by a reliance on wild fruits, seeds, nuts, berries, game, and fish, and avoiding the uncertainties produced by intensifying a seed-crop economy in a moist, tropical environment.

Paleoindian occupation is evidenced by a Clovis-like point, made of locally-available chalcedony. Archaic occupation, locally subsumed under the Fortuna Phase, was indicated by the remains of a campsite with two hearths, a considerable accumulation of cooking stones, and products of core-flake technology. The cooking stones and lithic technology, which clearly existed in the Archaic, continued essentially unchanged throughout all later phases up to the Spanish Conquest.

The beginning date of the earliest Formative settlements is unclear, but probably occurred sometime during the 3rd millennium B.C., and certainly by 2000 B.C. At that time the earliest eruption of Arenal Volcano buried house floors, activity areas, and artifacts at the Tronadora Vieja site.

It is clear that ceramic traditions in the Arenal area did not develop in isolation, although from the very beginnings of the Tronadora Phase the sequence is characterized by a decidedly local flavor, and clear continuities in form are apparent from one phase to the next.

The ceramic sequence suggests that the region was characterized by stability of population and culture, with little evidence for displacement, migration, or invasion. The quantity and distribution of ceramics, however, do suggest some significant demographic trends through the sequence. Sites with Arenal Phase ceramics vastly outnumber those of other phases, suggesting a peak population in the region between 500 B.C. and A.C. 600. Cemeteries were in special locations beyond the edges of villages, and marked with large numbers of river rocks, broken ceramic vessels, and elaborate metates. Footpaths linked villages with cemeteries.

Although the numbers and sizes of sites generally declined during the Silencio Phase, cemeteries were often located even farther from villages, and the deceased were given still more elaborate treatment. Polychrome pottery began to appear in the area, and, although relatively rare, the "Silencio Point" is an addition to the chipped stone inventory. A network of prehistoric footpaths, detected in remotely sensed imagery provided by NASA and by the Costa Rican Instituto Geographico, defined the links between the regional habitation sites, cemeteries, and natural resources.

The last phase of prehistory, the Tilaran, witnessed a break in the primary affiliation of the Cordillera with Greater Nicoya and artifacts show a generalized similarity with the cultures to the east and south. The settlement pattern was characterized by smaller and more dispersed hamlets. Ceramics were decorated by plastic surface modification rather than painting, and technical aspects of production declined.

As with comparable research done in El Salvador and in Panama, excavations focused upon Arenal area sites that were not buried by many meters of tephra, and thus difficult to discover and excavate. Sites at the other extreme, with a mere dusting of tephra, were avoided also, since they do not have as good preservation of features, artifacts, and structures or recognizable tephra layers for dating purposes. Emphasizing sites buried by moderate amounts of tephra (1–2 m) confers advantages in comparability, as similar depths of tephra have similar effects on the flora and fauna that were there just before the eruption (Segerstrom 1950; Rees 1979), and the similarities and differences in human responses can be investigated. A factor making comparisons more difficult is the scale of various eruptions; even though different sites may be buried by the same depth of tephra from different eruptions, the magnitude of eruptions and the areas covered by varying tephra depths need to be taken into account. Although we are far from understanding all significant variables, and having sufficient cases to be considered adequate samples, we can propose some initial working hypotheses.

The simpler Costa Rican societies apparently were more resilient than the more complex Salvadoran societies when affected by explosive volcanic eruptions, evidently because the latter relied more heavily on 1) the artificial, cultural environment; 2) depended to a greater extent on a domesticated staple crop; 3) had a more complex economy relying on commodities transported greater distances and involving redistribution; and 4) occupied settlements that were organized into vertical tiers reflecting social, political, and economic centralization (Sheets 1983).

The Barriles Chiefdom of western Panama was organized into two levels of villages, and while the society was less complex than that of El Salvador, at least some of the economy was under centralized control (Linares, Sheets, and Rosenthal 1975). Subsistence apparently was based on maize as a staple, and alluvial soils were strongly favored for settlement and agriculture. The eruption of Baru Volcano depopulated the upper reaches of the Rio Chiriqui Viejo, and may have been the impetus for settlement north of the continental divide on the Atlantic slope.

In both El Salvador and Panama the effects of the major eruptions (Ilopango and Baru, respectively) on human societies were sufficiently great to serve as phase or period boundaries, and the societies reoccupying the areas after the recovery of vegetation and soils were sufficiently different to warrant a taxonomic distinction. Such is not the case in Costa Rica; even though Arenal's explosive eruptions were separated by an average of four centuries, thus probably catching local populations as unprepared mentally and physically as were people during its most recent eruption in 1968, there is not a single eruption that can be correlated with a phase boundary. No Arenal eruption had a sufficient effect on nearby societies—whether by internal disruption or ecological impact, or by causing migration with culture change prior to reoccupation—to be recognizable in the cultural record.

The Baru tephra of Panama was thinner at occupied sites than most of the tephra layers in excavated Arenal area sites. The Ilopango tephra of El Salvador was comparable in thickness to Arenal tephra layers only at considerable distances from the source; evidence of the relatively small eruptions of Laguna Caldera, Boqueron, and Playon is locally more similar in scale to Arenal and Baru.

The strongest effect of volcanism on settlement detected in the Arenal area occurred with the deposition of Units 41 and 40, about A.C. 900, which coincided with, and may have caused a concentration of, settlements in the Rio Piedra valley. The tephra layers were thinner in the valley than in the Lake Arenal-Rio Arenal area, which thus may have served as a refuge area until soils and vegetation recovered in the areas closer to the volcano. In spite of the settlement changes, there appear to have been no significant alterations to culture, and, as mentioned earlier, no correlated phase or period boundaries can be recognized.

When compared to the cultural record of Mesoamerican, Andean, or other more complex Middle American cultures, the most striking feature of Arenal culture through the millennia is its stability—and that in spite of occasional stresses from volcanism or other factors. Arenal societies were simple egalitarian societies, with only a slight indication of a ranked society during the 1st millennium A.C. Both maintaining a diversified adaptation within the environment, with agriculture and use of a wide variety of wild food sources, and low population density probably aided societal resilience to ecological perturbation. Avoiding reliance on large fixed facilities such as irrigation systems, storage facilities, and large scale construction, probably improved people's abilities to cope with sudden ashfalls.

Some elements of adaptation were established during the Archaic Period, and remained essentially unchanged until the Spanish Conquest. For instance, an informal percussion core-flake technology, using locally available materials, successfully supplied cutting edges for some 5500 years. The use of locally-available stream cobbles for cooking continued over the same time span, in spite of the introduction of pottery sometime before 2000 B.C. Ceramics, so sensitive to change in most areas of the New World, are notable for stability as well. The village lifestyle, also established by 2000 B.C., changed only slightly as settlements expanded or contracted in size and frequency across the landscape. A trend toward more elaborate funerary practices is discernible from the earliest villages to about A.C. 1200. Arenal area residents evidently developed a sustained-yield agroecosystem by 2000 B.C., and continued that with only minor modifications until the Spanish Conquest.

Acknowledgments

This research has benefited from the assistance of numerous institutions and individuals in the United States and Costa Rica. The National Science Foundation (grant numbers BNS8310599, 8419879, 8520829, and 8616312) and the National Geographic Society (grant number 2728–83) provided funding, and their assistance is gratefully acknowledged. The Council on Research and Creative Work and the Institute of Behavioral Science, both of the University of Colorado, supported two preliminary visits to the area, without which the NSF and NGS proposals probably would not have been funded. The Museo Nacional de Costa Rica has been exceedingly helpful, and we would particularly like to thank Lorena San Roman, Marco Herrera, Lorena Aguilar, and Maritza Gutierrez. The Comision Nacional granted permission for the project. The Instituto Costarricense de Electricidad

(I.C.E.) was helpful in granting permission for research on their property around Lake Arenal. The Anthropology Department of the Universidad de Costa Rica was of assistance in a number of ways. Michael Snarskis resolved a variety of problems; Liz Knapp assisted greatly in correlating tephra deposits in the Tilaran-Arenal area with those in the El Tajo master section recorded by Melson. Robert and Patty Drolet provided a vehicle and housing in the early days of the project. Aida Blanco Vargas was very helpful in aiding the identification of archaeobotanical remains. Roberta Klausing Bradley and Nancy Mahaney Chenault were the Laboratory Supervisors during the 1984 and 1985 seasons, and their daily attention to detail was essential to our success. Earl and Barbara Bolton donated over three months of volunteer work in the laboratory, in mapping, and in drafting. Anthony Ranere shared information on recently-discovered Paleoindian remains in the Santa Maria area of Panama. Lynette Norr and James Ebert made many useful suggestions on an earlier version of this paper.

The landowners who granted permission for surveys and excavations are acknowledged, including Clara Corneli, Luis and Gabriella Jimenez, Tito and Fernando Calderon, and Yolanda Peraza. Our dedicated and hard-working crews of Costa Rican workers set high standards and were a pleasure to work with over the seasons. The contributions of Meredith Matthews, Karen Clary, Dolores Piperno, and Nancy Mahaney were essential to understanding prehistoric utilization of plants. The dedication of project members during difficult circumstances will be forever appreciated. To all the people who have made our research possible, a hearty *muchisimas gracias*.

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