Report of the 2009 Maya Agriculture Project, South of Joya de Cerén, El Salvador

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Chapter 1. Introduction.

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Prior to the 1960s, most archaeologists assumed low Classic period population densities throughout the Maya area, and it logically followed that extensive maize swidden agriculture was sufficient to supply the basic food needs. However, regional surveys since then have discovered dense populations, of hundreds of people per square kilometer. Paleodemographic and settlement knowledge has increased rapidly, but understanding how those populations fed themselves has lagged behind. Some large-scale features of intensive agriculture have been found, including swamp reclamation raised fields, terracing, and water control systems, and recently microscopic indicators of various species have been identified. Unfortunately, data on individual cultigens, details about field management, and agricultural productivity have been difficult to obtain.

Manioc cultivation among the Maya has remained controversial. Many scholars since the 1960s enthusiastically supported root crops as possible dietary components, particularly manioc. Others have pointed out the paucity of actual data of manioc cultivation among the ancient Maya. Some argued the Classic Maya cultivated no manioc, and stated it may have been introduced during the Postclassic period, or even by the Spanish from the Caribbean in colonial times. Microscopic examination of Belize sediments has detected manioc pollen by 3000 BC, and manioc starch grains were identified in Panama from ca. 4000-5000 BC. Macroscopic details of growth and cultivation have eluded archaeologists until recently. During preliminary research 200 meters south of the Cerén site in El Salvador, in June 2007, an intensive manioc cultivation plot was discovered in two test pits excavated through 3 m of volcanic ash. The 2009 research program was designed to examine the plot by studying planting, harvesting, and replanting techniques, caloric production per unit area, and field maintenance. Multiple lines of evidence of past manioc production were collected and will be compared, many of which can be found in other sites with more common kinds of preservation.

Maya Subsistence: Previous Interpretations

The predominant view of ancient Maya agriculture during the 19th and early-to-mid 20th centuries was of extensive swidden cultivation of maize, with beans and squash as secondary crops. Early travelers, such as Thomas Gage in the 17th century (Thompson 1958), and later Stevens and Catherwood (1841), observed the Maya successfully feeding dispersed populations by low intensity swidden cultivation. Early archaeologists extrapolated that back into Precolumbian times. Morley (1946) firmly implanted the swidden-maize-milpa model in our discipline by arguing that there had been no changes in agriculture over three millennia, and claiming it was the only form of agriculture possible in the Maya tropics because of the uniformly poor soils.

The challenge to this dominant interpretation came not from direct agricultural discoveries, but indirectly from paleodemography. During archaeological projects such as Tikal during the 1960s surveyors found vastly greater housemound densities, and by inference population densities, than previously believed existed (Willey 1982:4). Culbert and Rice (1990) summarize paleodemographic estimates of many hundreds of people per square kilometer at many Classic period sites derived from those surveys. By the 1960s it was clear that swidden was insufficient to feed such populations, and archaeologists accepted the challenge of seeking alternative agricultural strategies and cultigens practiced by the ancient Maya.

Bronson (1966) explored root crops as possible dietary supplements for the ancient Maya, and was in part responsible for a burst in enthusiasm for this subsistence alternative to maize. He documented manioc cultivation among seven out of 10 ethnographically recorded Maya groups. For instance, the Chorti, the closest Maya group to El Salvador today, cultivated manioc in fields separate from other crops (Wisdom 1940:56). In a brief visit to Jocotan and nearby Chorti Maya communities in 2009, we were unable to locate any such cultivation, as acculturation has been prominent during recent decades. The sellers of manioc tubers in the traditional market in Jocotan stated that manioc was still grown in isolated Chorti areas, but not in the central valley near Jocotan. Bronson (1966) also mentioned that the Maya word for manioc, "tz'iXn," was found in all major branches of Maya languages, indicating widespread utilization, and perhaps significant time depth. Flannery (1982:xix) noted the surge of interest in manioc among Mesoamericanists after Bronson's publication, but criticized scholars who "believed on faith [in Precolumbian manioc cultivation] because there is no archaeological evidence to support it." Flannery did note two ancient manihot seeds discovered in Tamaulipas and Chiapas, but stated that both may be wild. The evidence for Classic period Maya cultivation of manioc was so weak that Marcus (1982: 252) suggested outsiders may have introduced it during the Postclassic period, or even that the Spanish brought it into the area from the Caribbean during colonial times.

In their surge of enthusiasm for finding evidence of manioc cultivation, Mesoamerican archaeologists sought artifactual evidence, but they often did not think critically. For instance, Green and Lowe (1967: 128-9) found small obsidian flakes at Altamira, and suggested they might have been used for grating manioc. Unfortunately many Mesoamericanists, including Flannery (1982), and the authors of most Mesoamerican/Maya textbooks written since then, embraced the interpretation that the obsidian flakes were used in manioc grating. Many Mesoamerican archaeologists should have considered the cautionary insights of DeBoer (1975) and recently of Perry (2005) regarding the necessary toughness of known manioc grater chips based on their extensive experience with manioc. And I suggest that if the Altamira obsidian flakes actually were used to grate manioc, they would have fractured badly, inducing internal bleeding when passing through the digestive tract of the unfortunate consumer. The lithic "teeth" in known manioc grater boards are not made of brittle thin vitreous minerals. Further, bitter manioc usually is grated in Latin America, as the first step in detoxification, but sweet manioc need not be grated. The Maya manioc controversy, at its height in the 1970s and 80s, has subsided, at least partly because of frustration in finding direct and compelling evidence. Microscopic evidence of domesticated manioc in sediment cores in the Maya area and nearby (see below) indicates it was known to the Maya and must have been cultivated somehow. How, where, and how much, are our research foci.

Maya Subsistence: Recent and Current Understandings

In the most extensive compendium of the ancient Maya, Sharer (2006: 80-882) describes the current understanding of subsistence as a mixture of extensive and intensive techniques focusing on maize, beans, and squash. He notes that the Classic period population increase required more intensive techniques, including kitchen gardens, terracing, raised fields, and irrigation. He also favored the multi-species mosaic model of intercropping, mimicking the species diversity of the rainforest.

In the felicitously titled book <u>The Managed Mosaic</u> Fedick (1996) provides a detailed recent understanding of ancient Maya agriculture. The 28 authors provide many facts and cases consistent with Sharer's overview, and they document environmental heterogeneity in ways not imagined a decade or two before. Many chapters present large-scale agricultural intensification features such as terracing, raised fields, canals, and reservoirs, because they preserve better in tropical climates than do smaller features. And, not surprisingly, the domesticated plant species that have the greatest chances of being preserved in the archaeological record are featured, especially maize. The index provides 73 page references for maize, but only two for manioc. Both are by Cathy Crane (1996:271), and her point is how little evidence of cultivation of any root crop has been found among the Maya, and she concludes, "the role of root crops in the Maya diet is unknown." Miksieck (1991:180) identified some carbonized organic materials at Cuello as fragments of manioc stems, but he did not know if they were wild or domesticated. And Jones identified domesticated manioc pollen from a sediment core taken from Cobweb Swamp, but it is not well dated (Crane 1996). One manioc plant was found in previous Cerén research, in the Household 1 kitchen garden (Sheets and Woodward 2002), and a few isolated ones were found elsewhere, leading us to think that manioc provided little to the diet. That finding was consistent with historic Spanish observations that manioc was cultivated only in gardens, and not as a staple like maize in formal rows.

The best evidence of manioc in the Maya lowlands has come from microscopic examination of soils and sediments. Pohl et al. (1996) found probable domesticated manioc pollen in swamp cores from northern Belize, dating to about 3400 BC, and apparent domesticated manioc pollen was discovered more than a millennium earlier in nearby Tabasco (Pope et al. 2001). Manioc starch grains are even earlier in Panama, by c. 4000-5000 BC (Dickau et al. 2007). What have eluded archaeologists until recently are the cultivation details. Was manioc a minor cultigen in gardens, or was it a staple? Was manioc interplanted with other cultigens, or in single-species plots? Was it planted in beds? How carefully were planting beds prepared and maintained? Can individual cultivators and their plots be identified? Was manioc planted by seeds or stems, called 'stakes,' and if the latter, were they vertical, slanted, or horizontal? What was the caloric productivity per unit area, relative to other cultigens? How extensively and intensively was it cultivated? Might leaves have also been consumed? These are our research questions.

The 2007 Research Discoveries at Cerén

Well-preserved manioc planting beds were discovered south of Cerén during the 2007 National Geographic-sponsored research (Fig. 1-1, Test Pits 1 and 2). The theoretical framework for the project involves the interrelated domains of demography and agricultural intensification (Boserup 1965, 1981, Richards 1985), that people often adjust to increasing population densities by intensifying their agriculture. The Zapotitan valley was depopulated after the Ilopango eruption, but Cerén was part of the reoccupation, and Late Classic populations were quite dense, at c. 200-400 people/km^2 (Black 1983:82). More recent research on intensification has considered many factors beyond demography (Netting 1993, Stone 1990). Kunen et al. (2000) document demographic growth and agricultural intensification in the Peten wetlands, contemporary with Cerén. Most of the literature on agricultural intensification and theory building focuses on state level societies, but the literature on smallholders (e.g. Netting 1993) is pertinent to Cerén. Intensification among traditional smallholders consistently is more pronounced near their houselots, and usually diminishes with distance as one enters the outfields (Robert Netting pers. comm. 1985). Our hypothesis in 2007 was that agricultural intensification and productivity would decline in fields a few hundred meters south of the village.

The results did not support that hypothesis. All evidence encountered in 2007 indicated sustained intensity (Sheets et al. 2007). One pair of test pits found a high-performance maize milpa (Wilken 1971) with productivity similar to that documented within the site (Sheets and Woodward 2002), another pair found an area that had been agricultural and was converted to

Figure 1-1. Map of 2009 Research Area. Test Pits 1 and 2 excavated in 2007 are in the center.

open use, and the third pair found manioc. Maize intensity was maintained at a distance, and the manioc field may have greatly out produced all other cultigens in food per unit area.

The 2007 research proceeded in three stages: mapping the present surface of the research area, geophysical exploration with ground-penetrating radar, and excavating test pits in areas of interest (Sheets et al. 2007). The fortuitous anachronism created by the Loma Caldera volcanic eruption is that it preserves micro field features and growing plants extant at that moment, in spite of the 1400 years and myriad earthquakes that have intervened. Fine details, for example, individual hand marks of people shaping the planting beds were preserved by the eruption.

The manioc planting beds were encountered in Test Pits 1 and 2 (Fig. 1-1), each 2 x 3m, and 3m deep (Sheets et al. 2007). Compared to the maize ridges that we excavated in so many areas of Cerén (Lentz and Ramirez-Sosa 2002, Sheets and Woodward 2002), these manioc beds are massive. They are seven to ten times the volume of the maize ridges. But we were surprised to find nothing growing above the ridges, because the Loma Caldera tephra regularly preserves the stems of most growing plants larger than ½ cm in diameter, often to 50 cm above the Classic period ground surface, or higher. The answer was inside the 5 planting beds: the bushes had been cut and removed just before the eruption, and the basal portions of the trunks had been planted horizontally into the ridges to initiate the next round of growth. This had occurred the same day as the eruption, or just a few days before, based on our finding vertical and sometimes overhanging edges of the beds. The beds are composed of unconsolidated, slightly weathered volcanic ash from the Ilopango eruption, and that material cannot hold a vertical surface after it dries or after it is rained upon. Most of the manioc tubers had been harvested, but not all, as we occasionally found them as preserved hollows in the beds, and cast them with dental plaster. Dr. Nagib Nassar (Professor, Dept. of Genetics & Morphology, University of Brasilia), a major international authority on manioc, said the stalks we recovered were unusually robust, which would have resulted in abundant tuber production. Local agriculturalists said they are unable to grow manioc today as robust as these grown in Classic times.

The formality and the extent of the manioc beds indicate that manioc must have been a staple crop at Cerén. The single manioc plant in the kitchen garden of Household 1, and no other manioc plants in any other excavations within the village, indicated it was a garden plant, and a minor one at that. How wrong we were. The primary foci of the 2009 research were the extent, productivity, and variation of intensive manioc cultivation at Cerén.

The next chapters in this report describe and interpret the research results in terms of general categories. George Maloof presents the various cleared areas, and what we learned as to their functions. Then Andy Tetlow and Angie Hood focus on the maize fields ("milpas"). Christine Dixon discusses the richness of patterns and variation in the manioc fields. That is followed by a preliminary report on the paleoethnobotanical research by David Lentz and Angie Hood. In addition, George Maloof describes a new way he has innovated to do photomapping and photoprofiling of excavated areas, a way of georeferencing photographs of ground surfaces and of excavation walls. Finally, I summarize our research findings.

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I appreciate the willingness of the landowners (Santos Viuda de Galdamez, Juan Ramirez, and Santana) to allow us to excavate on their land, and disturb their crops. Fortuitously, much of the land was in fallow, during the dry season, but we did considerable damage to sugarcane on the Ramirez plot. Fortunately we were able to compensate for crop damage.

A deep debt of gratitude is owed Salvador Quintanilla ("Chamba") for his help in selecting the finest crew of workers that it is has been my pleasure to ever work with, in any country, in any season. They are a credit to their town and their country. They are: Julio Garcia, Salvador Carabante Ortega, Alejandro Granados, Antonio Carabante, Mario Evora, Amil Carbaja, Jose Campos, Nelson Alvarez, Jose Alvarez, Jose Guevara, Camilo Lopez, Ernesto Alvarez, Rigoberto Ramirez, Marvin Martinez, Juan Valencia, Vladimir Alvarez, Jose Ramirez, Willian Guerra, Carlos Martinez, Leandro Flores, Moises Rivas, Feliciano Paez, and Emilio Ramirez.

And what a fine crew of graduate students who shared the hard work with me in the dust and heat of the Salvadoran dry season: Christine Dixon, George Maloof, Andy Tetlow, and Angie Hood. Although field conditions were often trying, they performed on a professional level, which is both impressive and appreciated.

Chapter 2. Classic Period Maize Agriculture South of Joya de Cerén.

Andrew P. Tetlow
With Additions by Angela N. Hood

Introduction

The 2009 field season at Joya de Cerén continued to shed light on the specific extent, techniques, and types of agriculture that were practiced at this extremely valuable Classic period Maya site. The destruction by volcanic burial, while calamitous for the Maya residents, has provided a great deal of information about the day -to- day lives of the site's occupants. This remarkably preserved evidence is a result of the eruption of Loma Caldera Volcano1400 years BP and the sudden burial of the site beneath a great deal of highly destructive, but also very protective, volcanic ash. This has resulted in levels of preservation, particularly in the realm of agricultural production, which have not been seen at any other location in the Maya area. The site and the surrounding area of Cerén is a unique treasure for archaeology as well as the country of El Salvador and the world as a whole, as evidenced by Cerén's status as a United Nations World Heritage Site, the first and only such location in El Salvador. Nowhere else in the Maya area can such an accurate image of the day to day life of the ancient Maya people be captured and examined so closely and in such remarkable detail.

Aside from the unique preservation encountered across the site, this section will deal with the evidence relating to maize agriculture that has been painstakingly recovered during this most impressive, and continually surprising, field season. Each excavation unit that has exhibited evidence of maize will be discussed in detail. This will be accompanied by the location and extent of each sample of evidence that has been recovered. These excavations will also be examined within the context of the larger area as a whole in order to draw conclusions about the relationships between individual examples of maize agriculture and other forms of agricultural production that were occurring simultaneously in adjacent areas. For example, in the case of Operation G, this can be seen most clearly as there is a crisp delineation between examples of manioc production which then suddenly change into strictly maize agriculture. Surprising relationships and discoveries such as these are surely the hallmark of this field season and many other examples of such remarkable data will be examined below after a brief description of some prior research that has been conducted at Cerén site by Dr. Payson Sheets and colleagues.

Prior Maize Agricultural Research at Cerén Site

Excavations carried out in 1990 by Dr. Sheets, and described in the Preliminary Report of said season by Brian McKee, encountered a series of maize surcos beginning 2.6 meters from the eastern extent of Structure 9. The majority of the initial holes were located in Unit 3, and after casting and further detailed excavation it was discovered that these were maize plants (McKee 1990). Much of the evidence recovered was in the form of mature corn cobs, which ranged in length from 15-20cm (McKee 1990). These mature cobs were recovered with stalks doubled over, likely as an intentional agricultural harvesting technique to stop the flow of nutrients to the ear and all rain water to flow over the ear, helping it to dry (Sheets, personal communication 2009). The average height of the maize casts was 50cm to 80cm (McKee 1990), which roughly matches many of the results from the 2009 season, and the particular example of an intact and doubled over maize stalk complete with ear from Operation East.

Later excavations carried out in 1996, and also described by Brian McKee in that season's Preliminary Report, depicted an extension of the original excavations of 1990. The initial goal of these excavations was to locate Structure 8, however, excavations uncovered further evidence of the maize field first encountered in 1990. These excavations took place to the north of the previously uncovered field. One interesting article of evidence to note from the 1996 field season is that in this maize field a group of corn stalks (approximately 5) were discovered to have been tied together with twine (McKee 1996). This is a fascinating glimpse into some very specific agricultural techniques that were being employed. The reason for tying these stalks together is unclear, and McKee (1996) puts forth several explanations, including greater protection from wind and marking plants for seeding the following year (McKee 1996). The data of earlier excavations in maize fields at Cerén are similar but not identical to those of the 2009 field season.

Location

All of the excavations conducted during this field season took place to the south of the site center, in what is currently active agricultural land, mostly utilized in sugar cane production. The excavations took place across plots of land that are owned by several different individuals who deserve immense thanks for their willing and enthusiastic support and for the generous use of their land for the purpose of archaeological research. Without the assistance of these land owners it would have been impossible to excavate at all, and so much would remain unknown in relation to how the ancient Maya produced a variety of crops so many centuries ago.

The excavations for this field season used Test Pits 1 and 2 excavated during the previous field season (Dixon 2007) as a centerpoint for the layout of the four initial excavation units in 2009. To begin defining the limits of our area of interest, multiple excavations (all oriented due magnetic north) were based off of the initial findings of the first four pits of 2009. As the season progressed excavations began to contract back towards the 2007 test pits in order to further clarify the nature of the agricultural area being investigated, with particular focus on patterns and variability over short distances, the limits of individual plots of land, and the transition between manioc and maize agriculture.

Research Methodology

The methods employed for all the excavations conducted this season followed a highly specialized methodology and therefore demand a detailed explanation for the benefit of the readers of this report. The excavations were supervised by Christine Dixon, who recorded a very impressive and detailed collection of master notes related to every excavation, the use of which has been of no small assistance during the composition of this section. Christine's hard work and highly detailed recording of the progression of the excavations is very much appreciated by the entire crew.

A 3 x 3 meter pit was established for each Operation and the topmost oil (A-Horizon) was removed and kept isolated from the other tephra in order to minimize the effects of our excavations on future crop production. This A-Horizon ranged in thickness from approximately 20 to 50cm across the entire research area. A 12cm thick B-Horizon – characterized by a material coarser and darker than the A-Horizon – subtends the surface A-Horizon, although the thickness of the B-Horizon varies considerably across the research area. This is then followed by the C-Horizon, composed of a coarse, grayish matrix of pumiceous tephra which is derived from the eruption of El Playon in AD 1658-9 (Dixon 2007).

Excavation Methodology

The tools and methods used for excavation included picks, shovels and azadones for the topmost layers of tephra. However, when more sensitive layers were encountered more precise tools, such as trowels and whisk brooms, were utilized. These layers include the relatively hard, thick, and fine-grained light brown layer designated Unit 3 (which is where the initial evidence of virtually all plant cavities have been encountered during previous seasons since 1978); as well as the level of most central interest to this project, the Tierra Blanca Joven from the Ilopango eruption, also referred to as TBJ (Dixon 2007, Miller 1990).

The sensitive and highly fragile nature of TBJ necessitates very precise removal of the stratigraphically superior units, which was most ably and impressively done by our crew of both experienced and novice local workers. These workers were highly professional, dedicated, and interested in both preserving the archaeological evidence and the overall meaning of that evidence. A total of 21 workers were distributed as needed throughout all of the excavations, usually in teams of 4-6. In addition to this, two more experienced groups of individuals were established and trained to conduct the more detailed cleaning of the poured casts *in situ*, these two groups were referred to as Team A and Team B, and were deployed as necessary.

Much of the excavation conducted was done through the consecutive depositions of ash and other material from the eruption of Loma Caldera volcano (Dixon 2007). The in-field identification of these layers was facilitated by previous descriptions of the generalized stratigraphic sections of pyroclastic deposits (Miller 1990), which has proven an excellent guide for decisions of speed in excavation for each stratum. Units 3, 2, and 1 were all extremely sensitive horizons for these excavations, as these are the strata in which hollow plant cavities are preserved.

When small to large hollow cavities were encountered in Unit 3, the area was initially isolated while excavation around the cavity continued. In order to identify this location and prevent contamination or accidental destruction of the cavity, a small piece of newspaper was carefully inserted into the hole. In cases when a cavity was particularly curious or impressive, a fiber optic proctoscope was used to examine the interior of cavities in order to determine their extent, form, and the amount of plaster that would be required. This has only been done with cases in which the cavity is deduced to be particularly impressive or of significant importance.

Dental Plaster Methodology

The operations were excavated to Unit 3 and below before dental plaster was poured into the cavities. The probable extent and volume of the cavity was determined in order to estimate the amount of plaster needed to each hollow space. A plastic bag was then filled with an approximate amount of plaster and mixed to the proper consistency with water. The bottom corner of the bag was removed in order to form an easily controlled hole that can be quickly shut off with the index and forefinger of one hand, while the other hand held the weight of the bag and controlled the force of the flow. In exceptional cases of extremely large holes, a one to two gallon plastic bucket was used, as the volume of the plastic bags was not nearly enough to fill some of these extremely large cavities.

After the plaster set, which usually takes several hours depending upon conditions, the excavation of the actual cast commenced. Great care was used when excavating plant casts and special bamboo tools and small brushes were used for scraping and fine removal of tephra from each cast. In many cases, additional cavities were identified during these excavations. The cavities were filled at the earliest opportunity and after these secondary pours had been allowed to set excavation of the casts continued. Casts that lie directly atop (or beneath) the surface of the TBJ are left in situ and, if particularly remarkable, were carefully cleaned with water and toothbrushes in order to give the white dental plaster cast of the plant more contrast against the surface of the TBJ in photographs.

Recording and Labeling

The location of each cast was carefully recorded and each cast was given an individual identification number based on its location with the excavation. The identification number begins with the designation of the excavation (e.g. North) and with the Sub-Operation, which in most cases is 1. Following this, individual casts were then given an alphabetic identifier that is theirs alone. Then, casts that were grouped together were identified together as a cluster (e.g. Cluster 1). This methodology resulted in a designation such as N1A1. This signifies that this cast was from Operation North, Sub-Operation 1, and the individual cast (A) was the first from Cluster 1.

Within each excavation there were also a series of standardized measurements that were taken in order to accurately compare the differences, and similarities, between each excavation unit. The measurements consisted of the slope of both the surcos and calles (and platforms when necessary), the distance from ridge-top to ridge-top from each surco, the depth of each calle, and the directionality of the surcos. In the case of Operations G and L, these measurements were taken from both the manioc and maize surcos, as described below and in Tables 2-3 and 2-7.

Soil Sample Collection

Soil samples were collected into fabric sample bags and plastic Ziploc bags. For the most part samples were taken from the TBJ on top of the surco (planting ridge) and from the intervening calles (swales), as well as from the Preclassic (and correct all) clay directly beneath (ranging from 10-20cm in most cases) the TBJ in both the surcos and the calles. When other areas of significant interest were identified then samples were also collected from these locations. Two individual trowels were used for collection. The first was used to remove a thin layer (typically only a few centimeters) of soil to reach uncontaminated matrix. The second trowel was then rinsed with water and wiped clean several times and this was then used to collect a sterile sample, which was immediately placed in its proper sample bag. Additional soil samples were also collected from certain excavations by several highly skilled agricultural engineers from CENTA (Centro Nacional de Tecnologia Agropecuaria y Forestal , Laboratorio de Suelos), whose professionalism, assistance and advice on a number of complex agricultural issues are greatly appreciated.

Results: Excavations that Uncovered Evidence of Maize Agriculture

Operation East

The initial evidence of maize agriculture from this season was uncovered in Operation East, which provided several excellent maize casts, along with one remarkably preserved example of a bent over maize stalk with cob attached. Operation East was located 15 meters to the east of Test Pit 2 from the 2007 season (Dixon 2007). This operation revealed the most pristine examples of maize plants from the 2009 field season. The most impressive example of this evidence was a largely intact ear of maize that had been doubled over for harvest. This example showed great detail, including the ear and multiple stalks with fine preservation of coloration on portions of the casts.

This fine level of preservation can be seen throughout Operation East and is also quite evident in the relatively large number of maize stalk fragments that were also recovered from adjacent ridges. In particular, Cluster 6, in the western extent of the excavation contained a large number of well preserved stalk fragments, as can be seen in Table 1 and 2 below. The majority of these fragments exhibited the same high levels of preservation that we had come to expect from this operation, and this season in general. The remarkable coloration and texture that the casting process retained from the original cavity is truly astonishing. Very delicate features of the plant were visible in the casts including the fine striations of the stalk and the junctions between different stalks.

When the samples were carefully washed, with the utmost care being taken not to remove any of the valuable texture remnants and coloration, these features become even more apparent. As can be observed in Tables 1 and 2 below these same features are visible on almost every cluster from Operation East, however Cluster 6 has the highest density of these fine examples seen in the entirety of the excavation. It should be noted that while these outstanding examples may be found primarily in Operation East, this single unit did not encompass the entirety of maize evidence from this field season, as was clearly demonstrated in Operation G, which contained a wide variety of both manioc (Dixon, Chapter 4 of this report) and maize evidence.

Operation G

Operation G was located approximately 6 meters to the north-west of Operation East, and approximately 9 meters to the north-east of Test Pit 2 from the 2007 field season (Dixon 2007). The evidence of maize from plaster casting consisted primarily of samples of stalk fragments from Clusters 12 and 15 from the southern portion of the excavation (approximately 1 meter from the eastern excavation limit). These stalk fragments, for the most part, exhibit the same high levels of preservation as seen in Operation East. Texture and coloration were both clearly visible on a number of samples, as were the junctures between different sections of the stalks. This evidence acts as an excellent verification of the evidence recovered from Operations East, L, and O.

Operation G was interesting not only for the evidence of maize that it provided, which is substantial and spectacular, but also for the organizational information that we have been able to glean about the ancient Maya and their agricultural patterns. Operation G contains a clear and definitive separation between the planting of manioc and maize. The northern section of the operation (1-1.5 meters) contained three manioc surcos, as identified by the standardized measurements described in Table 2-3 (for further examples of manioc surcos see Chapter 4).

The remarkable finding of this operation was the identification of a transition between manioc and maize fields. The distinction of maize ridges and manioc surcos was again achieved through the standardized measurements highlighted in Table 3. The distinction of these fields is present not just in the size and shape of surcos, but also of calles. Such calles would have been utilized as both irrigation control and walkways. This division suggests at the very least a complex agricultural arrangement and perhaps also a rather intricate series of divisions between the property of different individuals or groups. In either case this is certainly remarkable evidence of agricultural organization in the fields south of the Cerén site.

Operation L

Operation L, sub-Operation 1 (referred to herein as L-1) was located approximately 4.5 meters east of Test Pit 2 from the 2007 field season (Dixon 2007) and 1.5 meters to the south of the southern excavation limit of Operation G. Operation L-1 revealed and further defined the separation between maize and manioc that was first described in Operation G has continued to further our understanding of the agricultural system that was in use by the Classic period Maya here at Cerén. The suggestion that this boundary continues to the south-west, along the same line as seen in Operation G, demonstrates that the separation (in this fashion) of manioc and maize is quite wide-spread and was by no means a small or isolated occurrence.

To further investigate the significant agricultural boundary between manioc and maize planting beds uncovered in Operation L-1, two 3 by 3 meter test units, Operations L-2 and L-3, were excavated to the north and south of Operation L-1, respectively. Once the TBJ surfaces of all three sub-operations were exposed, a total of eight manioc surcos were evident along the western portion of the field, with 14 maize ridges in the eastern portion of the field. The maize surcos in the eastern field were half the size of the manioc surcos in the western field, and two surcos fit into the space occupied by one manioc surco. The boundary between manioc and maize beds first described in Operation G continued throughout the expanded Operation L complex.

Twelve clusters of plant casts were recovered from Operation L-2, all of which were maize except for one manioc root complex recovered from surcos 7 and 8 of the western field. In Operation L-3, ten clusters of plant casts were excavated, and most of these casts were maize stalks. Six casts of manioc stems were also identified in Operation L-3.

The plaster casts created from Operation L were markedly less impressive and generally lower in quality than the casts recovered elsewhere in the 2009 season. This difference is likely due to differences in the plaster mixture and perhaps preservation of the cavities. Despite these differences, some casts still show evidence of slight coloration and texture details, including subtle impression of stalk junctures. Importantly, the division between the manioc and maize fields of this region was apparent.

Operation O

Operation O was located approximately 35 meters to the west north west of Operation L and approximately 27 meters to the west of 2007 Test Pit 2 (Dixon 2007). Erosion in Operation O made the readily visible surcos and calles more difficult to identify. There were approximately 12 ridges, which were spaced approximately 70 cm apart, and these surcos produced some maize plaster casts. The casts show some evidence of weeds, but the majority of these casts were corn. Much less evidence for maize was recovered from Operation O, which suggests that this might have been a more juvenile field than those documented in Operations East, G, and L.

Operation P

Operation P, located 38 meters southeast of the northwest corner of Operation K, was excavated to investigate whether the alignment of manioc surcos and calles (approximately 124°) uncovered in Operation K continued to the east. The TBJ surface of Operation P did not reveal a continuation of the surcos and calles found in Operation K, but rather unearthed a midden, or basurero, lying 6 centimeters below, measuring approximately 3 meters north-south by 2 meters east-west. While an abundance of ceramics, obsidian blade fragments, lajas, and paleoethnobotanical macroremains were identified in this midden, little evidence of maize agriculture was present in Operation P. However, one cast of a possible maize stalk excavated from Cluster 4 likely represents a volunteer maize plant, the seed of which may have germinated in the rich midden soil after it was discarded. The plant casts excavated from the eight other clusters – most of which are unidentifiable, with the exception of two manioc stocks – are also likely volunteers growing in the midden.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Sample**	**Dist N Wall**	**Dist E Wall**	**Description**
East	1	A	1	20cm	40cm	Maize Stalk Frag
East	1	B	1	20cm	40cm	Maize Stalk Frag
East	1	C	1	20cm	40cm	Maize Stalk Frag
East	1	D	1	20cm	40cm	Maize Stalk Frag
East	1	E	1	20cm	40cm	Maize Stalk Frag
East	1	F	1	20cm	40cm	Maize Stalk Frag
East	1	A	2	90cm	60cm	Maize bent over in harvest with stalks and maize bear
East	1	A	3	80cm	230cm	Maize Stalk Frag
East	1	B	3	70cm	220cm	Maize Stalk Frag
East	1	C	3	75cm	225cm	Maize Stalk Frag
East	1	A	4	140cm	100cm	Maize Stalk Frag
East	1	B	4	140cm	110cm	Maize Stalk Frag
East	1	C	4	150cm	110cm	Maize Stalk Frag
East	1	A	5	190cm	0cm	Maize Stalk Frag Horiz. in Eastern wall
East	1	B	5	190cm	0cm	Maize Stalk Frag
East	1	C	5	200cm	10cm	Maize Stalk Frag
East	1	A	6	120cm	280cm	Maize Stalk Frag (top)
East	1	B	6	120cm	280cm	Maize Stalk Frag
East	1	C	6	130cm	280cm	Maize Stalk Frag
East	1	D	6	130cm	280cm	Maize Stalk Frag
East	1	E	6	130cm	280cm	Maize Stalk Frag
East	1	F	6	130cm	280cm	Maize Stalk Frag
East	1	G	6	130cm	280cm	Maize Stalk Frag
East	1	H	6	130cm	280cm	Maize Stalk Frag
East	1	I	6	130cm	280cm	Maize Stalk Frag

East	1	J	6	130cm	280cm	Maize Stalk Frag
East	1	K	6	130cm	280cm	Maize Stalk Frag
East	1	L	6	130cm	280cm	Maize Stalk Frag
East	1	M	6	130cm	280cm	Maize Stalk Frag
East	1	N	6	130cm	280cm	Maize Stalk Frag
East	1	A	7	180cm	180cm	Maize Stalk Frag
East	1	B	7	180cm	180cm	Maize Stalk Frag
East	1	A	10	280cm	140cm	Maize Stalk Frag
East	1	B	10	280cm	140cm	Maize Stalk Frag (portions of 3 stalks)
East	1	C	10	280cm	140cm	Maize Stalk Frag
East	1	D	10	280cm	140cm	Maize Stalk Frag
East	1	E	10	280cm	140cm	Maize Stalk Frag
East	1	F	10	280cm	140cm	Maize Stalk Frag
East	1	G	10	280cm	140cm	Maize Stalk Frag

Table 2-1. Provenience of Maize Casts in Operation East.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Samp**	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Description**
East	1	A	1	14.6	1.2	1	Maize Stalk Frag (top portion)
East	1	B	1	11.9	1.5	1.5	Maize Stalk Frag (top portion)
East	1	C	1	10.5	1.3	1.2	Maize Stalk Frag
East	1	D	1	10	1.5	1.2	Maize Stalk Frag (top portion)
East	1	E	1	13.4	1.6	1.4	Maize Stalk Frag (top portion)
East	1	A	3	13.3	1.8	1.7	Maize Stalk Frag (with color and texture along most of the shaft)

East	1	B	3	4.6	1.8	1.7	Maize Stalk Frag
East	1	C	3	6.7	1.3	1.2	Maize Stalk Frag (with color along all of the sample length)
East	1	A	4	8.4	1.6	1.3	Maize Stalk Frag (slight texture near the sample end point)
East	1	B	4	8.1	2.1	1.6	Maize Stalk Frag (with Stalk juncture 2.9cm below pour point)
East	1	C	4	7.5	1.9	1.3	Maize Stalk Frag (with three localized areas of coloration)
East	1	A	5	33.2	2.9	2.1	Maize Stalk Frag
East	1	B	5	19.9	1.8	1.3	Maize Stalk Frag (top portion): with bend at the bottom of the frag. and 3 off-shoots
East	1	C	5	16.5	2	1.6	Maize Stalk Frag (two combined at the joint)
East	1	A	6	8.2	1.7	1.8	Maize Stalk Frag (cone-shaped)
East	1	B	6	3.7	2.2	1.5	Maize Stalk Frag (with coloration and texture)
East	1	C	6	11.1	2.6	2.5	Maize Stalk Frag
East	1	D	6	6.4	1.2	1.1	Stalk Frag With bend in it
East	1	E	6	11.2	2.3	2.1	Maize Stalk Frag (with vivid coloration and groove running the length of the

							sample)
East	1	F	6	8.7	1.6	1.2	Maize Stalk Frag (with vivid coloration and depression running the length of the sample)
East	1	G	6	9.2	1.3	1.2	Maize Stalk Frag (with coloration and depression)
East	1	H	6	5.4	1.5	1.3	Maize Stalk Frag (slight coloration)
East	1	I	6	10.1	1.8	1.2	Maize Stalk Frag (coloration)
East	1	J	6	5.2	2.2	1.5	Maize Stalk Frag (with coloration and depression running the length of the sample)
East	1	K	6	12.1	2.3	1.5	Maize Stalk Frag (with coloration and depression running the length of the sample)
East	1	L	6	6.2	2.3	1.8	Maize Stalk Frag (slight coloration)
East	1	M	6	13.2	8.4	3.2	Plant Cast Frag (Irregular, thin, and disc-like)
East	1	N	6	6.9	2.6	2	Maize Stalk Frag (with small area of leaf impression)
East	1	A	7	10.1	4.9	3.3	Maize Ear Frag
East	1	B	7	6	4.6	4.2	Maize Ear Frag
East	1	A	10	22	2.3	1.6	Maize Stalk Frag

East	1	B	10	12	2	1.9	Maize Stalk Frag
East	1	C	10	4.5	1.7	1.5	Maize Stalk Frag
East	1	D	10	7.1	1.9	1.2	Maize Stalk Frag
East	1	E	10	7.5	1	0.8	Maize Stalk Frag (associated with E1F10)
East	1	F	10	6.1	1.4	1	Maize Stalk Frag (associated with E1E10)
East	1	G	10	22.5	9	8	Maize Stalk Frags (Juncture of 3 Stalks connected by Unit 2 matrix)

Table 2-2. Measurements of Maize Casts Recovered from Operation East.

Operation	**Direction**	**Slope**	**Frequency of Ridge-Tops**	**Surco Height**
East	120°	7°	74 cm	12 cm

Table 2-3. Standardized Measurements for Operation East.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Sample**	**Dist N Wall**	**Dist E Wall**	**Description**
G	1	B	1	2cm	2cm	Plant Cast
G	1	C	1	2cm	2cm	Plant Cast
G	1	A	2	0	130cm	Plant Cast
G	1	B	2	0	130cm	Plant Cast
G	1	A	3	42cm	240cm	Very Long Tuber Frag
G	1	B	3	10cm	194cm	Long Thin Plant Cast (directly below G1A3)
G	1	C	3	25cm	198cm	Small Mushroom Shaped Plant Cast
G	1	D	3	18cm	246cm	Small "S" Shaped Plant Cast
G	1	A	4	0	84cm	Plant Cast
G	1	A	5	25cm	170cm	Plant Cast
G	1	B	5	38cm	150cm	Hollow Plant Frag

G	1	C	5	30cm	155cm	Large Root Frag
G	1	A	6	50cm	185cm	Tall "T" Shaped Plant Cast
G	1	B	6	50cm	185cm	"T" Shaped Plant Cast
G	1	A	7	85cm	58cm	Plant Cast
G	1	B	7	85cm	58cm	Plant Cast
G	1	A	8	130cm	0cm	Plant Cast
G	1	B	8	130cm	0cm	Plant Cast
G	1	C	8	130cm	0cm	Plant Cast
G	1	A	9	50cm	298cm	Plant Cast
G	1	B	9	42cm	60cm	Cone Shaped Plant Cast
G	1	A	10	145cm	205cm	Plant Cast
G	1	A	11	146cm	130cm	Plant Cast
G	1	B	11	150cm	140cm	Plant Cast Frag
G	1	C	11	150cm	140cm	Plant Cast
G	1	D	11	150cm	140cm	Plant Cast
G	1	A	12	180cm	68cm	Maize Stalk Frag with Large Base
G	1	B	12	180cm	68cm	Maize Stalk Frag
G	1	C	12	180cm	68cm	Maize Stalk Frag
G	1	D	12	180cm	68cm	Maize Stalk Frag
G	1	E	12	180cm	68cm	Maize Stalk Frag
G	1	F	12	180cm	68cm	Maize Stalk Frag
G	1	G	12	180cm	68cm	Maize Stalk Frag
G	1	H	12	180cm	68cm	Maize Stalk Frag
G	1	I	12	180cm	68cm	Maize Stalk Frag
G	1	A	13	220cm	0	Maize Stalk Frag
G	1	B	13	220cm	0	Maize Stalk Frag
G	1	C	13	220cm	0cm	Maize Stalk Frag
G	1	D	13	220cm	0cm	Maize Stalk Frag
G	1	A	14	214cm	156cm	Plant Cast
G	1	B	14	214cm	156cm	Plant Cast
G	1	A	15	244cm	90cm	Maize Stalk Frag
G	1	B	15	244cm	90cm	Maize Stalk Frag
G	1	C	15	244cm	90cm	Maize Stalk Frag

G	1	D	15	244cm	90cm	Maize Stalk Frag
G	1	E	15	244cm	90cm	Maize Stalk Frag
G	1	A	16	220cm	270cm	Plant Cast
G	1	B	16	230cm	274cm	"Y" Shaped Plant Cast
G	1	C	16	232cm	290cm	Thin Plant Cast Fragment
G	1	D	16	230cm	274cm	Small Cone Shaped Plant Cast
G	1	A	17	285cm	180cm	Maize Stalk Frag
G	1	B	17	285cm	180cm	Maize Stalk Frag with Leaf Impression
G	1	C	17	285cm	180cm	Maize Stalk Fragment
G	1	D	17	285cm	180cm	Maize Stalk Fragment
G	1	A	18	300cm	264cm	Small "P" Shaped Plant Cast
G	1	A	19	170cm	290cm	"C" Shaped Plant Cast
G	1	A	20	170cm	240cm	Long Tuber Frag with 7 Associated Fragments
G	1	B	20	180cm	240cm	Long Tuber Frag
G	1	A	21	270cm	270cm	Long Thin Plant Cast
G	1	A	22	30cm	292cm	Large Plant Cast

Table 2-4. Provenience of Maize Casts in Operation G.

Operation	**Sub.Op.**	**Field Spec.**	**Cluster Samp**	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Description**
G	1	A	1	11.4	2	1.8	Maize Stalk Frag (Two parti stalks connected)
G	1	B	1	5	1.5	1.2	Maize Stalk Frag (Top Portion)
G	1	C	1	10	1.8	1.6	Maize Stalk Frag (with portions of two stalks attached by plaster in Unit 2 tephra)
G	1	A	4	4.9	0.7	0.7	Maize Stalk Frag (Small Top Portion)

G	1	B	6	8.8	1.1	1.1	Maize Stalk Frag
G	1	A	7	17	1.1	1.1	Maize Stalk Frag
G	1	B	8	4	1	1	Maize Stalk Frag (with horizontal growth/ leaf impression)
G	1	A	11	20.5	0.9	0.9	Thin Maize Stalk Frag with Texture, Color, and Juncture
G	1	B	11	8.3	1.4	1.3	Small Maize Stalk Frag with slight Texture and Stalk Juncture
G	1	D	11	8.8	1.4	1.5	Small Maize Stalk Frag
G	1	A	12	14.5	1.5	1.3	Maize Stalk Frag With Large Area of Unit 2 and three other associated Stalk Fragments
G	1	B	12	13	1.6	1.5	Maize Stalk Frag
G	1	C	12	11.8	1.6	1.4	Maize Stalk Frag
G	1	D	12	13.9	1.4	1.3	Maize Stalk Frag
G	1	E	12	5.5	1.6	1.3	Maize Stalk Frag
G	1	F	12	6.9	1.2	1.1	Maize Stalk Frag (top portion)
G	1	G	12	5.9	1.3	1.1	Maize Stalk Frag (top portion)
G	1	H	12	8.4	1.8	1.2	Maize Stalk Frag (with portion of a bent Stalk)
G	1	I	12	15.2	1.5	1.4	Maize Stalk Frag (top portion with portion of a

							bent Stalk)
G	1	A	13	7.5	1.5	0.75	Small Maize Stalk Frag
G	1	B	13	14.5	3.9	4	Maize Stalk Frag
G	1	C	13	5.9	1.5	1.2	Maize Stalk Frag (top portion)
G	1	D	13	10.3	1.5	1.2	Maize Stalk Frag (top portion)
G	1	A	14	6.7	2	1.1	Maize Stalk Frag (with coloration near the pour point)
G	1	B	14	4.2	1	1	Maize Stalk Frag (slight coloration and Stalk juncture at the midpoint of sample)
G	1	A	15	6.2	1.5	1.5	Maize Stalk Frag (top portion)
G	1	B	15	9.5	1.6	1.6	Maize Stalk Frag (top portion)
G	1	C	15	9	1.2	1.2	Maize Stalk Frag (top portion)
G	1	D	15	14	1.5	1.2	Maize Stalk Frag (top portion)
G	1	E	15	6.3	1.6	1.6	Maize Stalk Frag (top portion)
G	1	A	17	14	2.6	1.7	Maize Stalk Frag (top portion)
G	1	B	17	8	1.7	1.4	Maize Stalk Frag (with large section of Unit 2 attached)
G	1	D	17	13	0.9	0.9	Maize Stalk Frag (in two sections)

Table 2-5. Measurements of Maize Casts Recovered from Operation G.

Operation	Direction	Slope	Frequency of Ridge-Tops	Surco Height
G: Maize Surcos	115°	7°	70 cm	11 cm
G: Manioc Surcos	120°	5°	114-120 cm	24 cm

Table 2-6. Standardized Measurements for Operation East.

Operation	Sub.Op.	Field Specimen	Cluster Sample	Dist N Wall	Dist E Wall	Description
L	1	A	1	55cm	2cm	Maize stalk fragment
L	1	B	1	55cm	2cm	Maize stalk fragment
L	1	C	1	55cm	2cm	Maize stalk fragment
L	1	D	1	55cm	2cm	Maize stalk fragment
L	1	A	7	297cm	100cm	Maize stalk fragment
L	1	B	7	297cm	100cm	Maize stalk fragment
L	1	C	7	297cm	100cm	Maize stalk fragment
L	1	D	7	297cm	100cm	Maize stalk fragment
L	1	E	7	297cm	100cm	Maize stalk fragment
L	2	A	1	215cm	40cm	Maize stalk fragment
L	2	B	1	215cm	40cm	Maize stalk fragment
L	2	C	1	215cm	40cm	Maize stalk fragment
L	2	I	2	160cm	295cm	Maize stalk fragment
L	2	A	3	204cm	154cm	Maize stalk fragment
L	2	B	3	204cm	154cm	Maize stalk fragment
L	2	C	3	204cm	154cm	Maize stalk fragment
L	2	D	3	204cm	154cm	Maize stalk fragment
L	2	E	3	204cm	154cm	Maize stalk fragment
L	2	F	3	204cm	154cm	Maize stalk fragment
L	2	A	4	140cm	140cm	Maize stalk fragment
L	2	B	4	140cm	140cm	Maize stalk fragment
L	2	C	4	140cm	140cm	Maize stalk fragment

L	2	D	4	140cm	140cm	Maize stalk fragment
L	2	E	4	140cm	140cm	Maize stalk fragment
L	2	F	4	140cm	140cm	Maize stalk fragment
L	2	A	5	70cm	110cm	Maize stalk fragment
L	2	A	6	103cm	92cm	Maize stalk fragment
L	2	A	8	198cm	130cm	Top of maize stalk fragment
L	2	B	8	198cm	130cm	Maize stalk fragment
L	2	C	8	198cm	130cm	Maize stalk fragment
L	2	D	8	198cm	130cm	Maize stalk fragment
L	2	E	8	198cm	130cm	Maize stalk fragment
L	2	F	8	198cm	130cm	Maize stalk fragment
L	2	G	8	198cm	130cm	Maize stalk fragment
L	2	H	8	198cm	130cm	Maize stalk fragment
L	2	A	9	160cm	70cm	Maize stalks-two connected by Unit 2
L	2	B	9	160cm	70cm	Maize with prop roots – connects with L-2-A-9
L	2	A	10	200cm	10cm	Top of maize stalk
L	2	B	10	200cm	10cm	Top of maize fragment
L	2	C	10	200cm	10cm	Maize cob and stalk fragments
L	2	D	10	200cm	10cm	Maize stalk fragment
L	2	E	10	200cm	10cm	Very top of maize stalk
L	2	F	10	200cm	10cm	Maize stalk fragment
L	2	G	10	200cm	10cm	Maize stalk fragment
L	3	A	5	80cm	132cm	Maize stalk fragment
L	3	B	5	80cm	132cm	Maize stalk fragment

L	3	C	5	80cm	132cm	Maize stalk fragment
L	3	D	5	80cm	132cm	Maize stalk fragment
L	3	A	6	42cm	42cm	Maize stalk fragment
L	3	B	6	42cm	42cm	Maize stalk fragment
L	3	A	7	102cm	92cm	Maize stalk fragment
L	3	B	7	102cm	92cm	Maize stalk fragment
L	3	C	7	102cm	92cm	Maize stalk fragment
L	3	D	7	102cm	92cm	Maize stalk fragment with Unit 2 attached
L	3	E	7	102cm	92cm	Maize stalk fragment
L	3	F	7	102cm	92cm	Maize stalk fragment
L	3	G	7	102cm	92cm	Maize stalk fragment
L	3	H	7	102cm	92cm	Maize stalk cluster – at least 5 stalks
L	3	I	7	102cm	92cm	Maize stalk fragment
L	3	A	8	140cm	36cm	Maize stalk fragment
L	3	A	10	210cm	160cm	Maize stalk fragment with at least 2 stalks connected at Unit 2
L	3	B	10	210cm	160cm	Maize stalk fragment
L	3	A	11	260cm	246cm	Maize stalks of Surco 1 in lower field
L	3	B	11	260cm	246cm	Maize stalks of Surco 1 in lower field

Table 2-7. Provenience of Maize Casts in Operation L.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Samp**	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Description**
L	1	A	1	7.6	1.7	1.2	Maize stalk fragment

L	1	B	1	4.5	1.5	1	Maize stalk fragment
L	1	C	1	12.5	1.9	1.7	Maize stalk fragment
L	1	D	1	22.5	1.8	1.5	Maize stalk fragment
L	1	A	7	4.3	1.7	1.1	Maize stalk fragment
L	1	B	7	15.1	1.6	1.2	Maize stalk fragment
L	1	C	7	12	0.9	0.8	Maize stalk fragment
L	1	D	7	18.5	1.4	1	Maize stalk fragment
L	1	E	7	8.1	1	0.8	Maize stalk fragment
L	2	A	1	6.5	1	0.8	Maize stalk fragment
L	2	B	1	4	1.1	1	Maize stalk fragment
L	2	C	1	3	1.1	1	Maize stalk fragment
L	2	I	2	12	1.5	1.4	Maize stalk fragment
L	2	A	3	7.8	1	0.8	Maize stalk fragment
L	2	B	3	6.8	0.9	0.8	Maize stalk fragment
L	2	C	3	5.8	1	1	Maize stalk fragment
L	2	D	3	6	0.6	0.6	Maize stalk fragment
L	2	E	3	5	2	1.5	Maize stalk fragment
L	2	F	3	12.5	1.5	1.4	Maize stalk fragment
L	2	A	4	6.2	1.9	1.8	Maize stalk fragment

L	2	B	4	6	1	1	Maize stalk fragment
L	2	C	4	4.5	1.1	1	Maize stalk fragment
L	2	D	4	14	1.8	1.6	Maize stalk fragment
L	2	E	4	24	1	0.9	Maize stalk fragment
L	2	F	4	2.7	1.8	1.5	Maize stalk fragment
L	2	A	5	7.4	1.9	1.3	Maize stalk fragment
L	2	A	6	19	2.4	2	Maize stalk fragment
L	2	A	8	5	1.4	1.3	Top of maize stalk fragment
L	2	B	8	10	2.1	1.6	Maize stalk fragment
L	2	C	8	8.8	2.3	1.8	Maize stalk fragment
L	2	D	8	14.1	1.3	1.1	Maize stalk fragment
L	2	E	8	8.8	1.9	1.7	Maize stalk fragment
L	2	F	8	4.2	1.4	1.2	Maize stalk fragment
L	2	G	8	7.1	1.5	1.3	Maize stalk fragment
L	2	H	8	4.1	1.9	1.7	Maize stalk fragment
L	2	A	9	22	2.3	2	Maize stalks- two connected by Unit 2
L	2	B	9	10.8	1.5	1.3	Maize with prop roots – connects with L-2-A-9
L	2	A	10	26	1.5	0.9	Top of maize stalk
L	2	B	10	4	1.5	1.5	Top of maize fragment

L	2	C	10	9.5	3.3	3	Maize cob and stalk fragments
L	2	D	10	6.1	1	0.7	Maize stalk fragment
L	2	E	10	2.6	1	1	Very top of maize stalk
L	2	F	10	6	1.1	1	Maize stalk fragment
L	2	G	10	4.5	1.1	0.7	Maize stalk fragment
L	3	A	5	10 (total L-3-A-5 to L-3-D-5)	1	0.9	Maize stalk fragment
L	3	B	5	10 (total L-3-A-5 to L-3-D-5)	1	0.9	Maize stalk fragment
L	3	C	5	10 (total L-3-A-5 to L-3-D-5)	1	0.9	Maize stalk fragment
L	3	D	5	10 (total L-3-A-5 to L-3-D-5)	1	0.9	Maize stalk fragment
L	3	A	6	4.5	0.9	0.7	Maize stalk fragment
L	3	B	6	8.6	1.5	1.1	Maize stalk fragment
L	3	A	7	6.5	1.6	1.5	Maize stalk fragment
L	3	B	7	12.4	1.6	1.2	Maize stalk fragment
L	3	C	7	5.1	1.1	0.9	Maize stalk fragment
L	3	D	7	6.6	1.6	1.4	Maize stalk fragment with Unit 2 attached
L	3	E	7	5.2	1	0.8	Maize stalk fragment
L	3	F	7	9.2	0.7	0.7	Maize stalk fragment
L	3	G	7	6	1.1	0.9	Maize stalk fragment
L	3	H	7	28	1.5	1	Maize stalk cluster – at least 5 stalks

L	3	I	7	7.2	1	1	Maize stalk fragment
L	3	A	8	6.6	1	0.9	Maize stalk fragment
L	3	A	10	16.5	1.7	1.6	Maize stalk fragment with at least 2 stalks connected at Unit 2
L	3	B	10	5	2.1	1.9	Maize stalk fragment
L	3	A	11	4.9	1.3	1.3	Maize stalks of Surco 1 in lower field
L	3	B	11	3.8	1.4	1.1	Maize stalks of Surco 1 in lower field

Table 2-8. Measurements of Maize Casts Recovered from Operation L.

Operation	**Direction**	**Slope**	**Frequency of Maize / Manioc Ridge-Tops**	**Maize Surco Height**	**Manioc Surco Height**
L-1: Maize and Manioc Surcos	58° West of Magnetic North	10°	74cm / 117cm	10cm	22cm
L-2: Maize and Manioc Surcos	58° West of Magnetic North	6°	74cm / 117cm	10cm	22cm
L-3: Maize and Manioc Surcos	58° West of Magnetic North	6°	74cm / 117cm	10cm	22cm

Table 2-9. Standardized Measurements for Operation L.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Sample**	**Dist N Wall**	**Dist E Wall**	**Description**
O	1	A	1	250cm	230cm	Maize Stalk Frag with Unit 2 Attached
O	1	A	5	162cm	132cm	Maize Stalk Frag
O	1	A	7	98cm	230cm	Maize Stalk Frag Cluster

Table 2-10. Provenience of Maize Casts in Operation O.

Operation	**Sub.Op**	**Field Specimen**	**Cluster Samp**	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Description**
O	1	A	1	19.8	1.3	1.1	Maize stalk fragment with Unit 2 attached

O	1	A	5	6.2	1.1	0.9	Maize stalk fragment
O	1	A	7	11.9	12	4.1	Maize stalk fragment cluster

Table 2-11. Measurements of Maize Casts Recovered from Operation O.

Operation	**Direction**	**Slope**	**Surco Height**
O-1: Maize Surcos	49° West of Magnetic North	9°	Range between 1-5 cm

Table 2-12. Standardized Measurements for Operation O.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Sample**	**Dist N Wall**	**Dist E Wall**	**Description**
P	1	A	4	32cm	252cm	Possible maize stalk

Table 2-13. Provenience of Maize Casts in Operation P.

Operation	**Sub.Op.**	**Field Specimen**	**Cluster Samp**	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Description**
P	1	A	4	9.8	1.2	1.2	Possible maize stalk

Table 2-14. Measurements of Maize Casts Recovered from Operation P.

Discussion and Conclusion

The excavations of this season in the agricultural fields south of Cerén site has certainly been a memorable and exciting one, both for we as participants, and hopefully for the archaeological community as a whole. The new method of photomapping (see Chapter 5) practiced as a regular part of this project has extended archaeological field techniques. Photomapping has saved a considerable amount of time and energy and will hopefully spread throughout the field and be utilized to its fullest potential.

As far as the evidence that has been uncovered, maize agriculture certainly occupies a clearly important and vital position in the overall agricultural plan for the ancient Maya who were living at Cerén. However, this is also tempered by the fact that while maize agriculture was taking place there was also extremely intensive and equally vital manioc agriculture being conducted alongside maize agriculture. This suggests no small amount of agricultural organization on the part of the ancient Maya living at Cerén site. The astonishing level of preservation at Cerén has provided us with a great deal of information that would not be available under normal taphonomic circumstances.

The unique conditions present here should surely be carefully examined and the data used to infer what types and systems of agriculture may have been practiced at other sites in the Maya area. While this is certainly not a direct indicator of what *must* have been occurring at other

Maya sites, it is surely an excellent modeling tool for future comparison. Future field season at Cerén should continue to shed much needed light on the organization of ancient Maya agriculture and other aspects of daily Maya life at a place that had the unique archaeological fortune of being frozen at a calamitous moment in the lives of individuals who have fascinated scholars, students, and laypersons for many lifetimes.

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<u>Acknowledgements</u>

Andy's hard work and dedication to archaeological research at Cerén produced most of this chapter, but evidence of maize agriculture was discovered in Operations L, P and O after his departure from El Salvador on February 21. I (Angela) joined the Cerén project on February 22, and Dr. Sheets gave me the opportunity to update Andy's chapter to include details of the surcos, calles, and plant casts uncovered in Operations L, P, and O, which has been quite a pleasurable experience. The following acknowledgements are Andy's.

Thanks for the success of this project go to a great many individuals, but by far the individual who is owed the most gratitude, from this author's perspective, is Dr. Payson Sheets. His relentless drive to discover how the site of Cerén functioned at a very practical level inspires the rest of the archaeological community to follow the example that he sets forth. His good humor and easy nature in all situations makes for an extremely pleasing and enjoyable field season, particularly from the perspective of a student. The contributions that he has made to this authors individual store of knowledge about both the Maya and archaeological field techniques will surely be used and appreciated far into the future in a wide variety of applications.

Special thanks should also go to fellow students, and friends, Christine Dixon and George Maloof. Christine provided a great deal of support in the writing of this section and it is greatly appreciated. Her ability and expertise in the field provided clarity and determination in all aspects of the season. Her easy and calm nature is much appreciated, as well as her desire to get things done and accomplish the mission while still remaining relaxed and good natured. Also, thank you Christine for taking the time to explain patiently any number of questions this author asked throughout the field season. This makes it so much easier for someone who has not worked around such a unique type of archaeological evidence to learn the specific techniques that are needed for careful handling of this material. I look forward to hearing of your many future successes.

George Maloof has also provided a great deal of support to this author and has acted as an excellent sounding board for a wide range of ideas on a variety of topics. George's humor and relaxed nature made him a true pleasure to work with. Surely his contributions to archaeology (which are already well underway) in both Costa Rica and the Maya area, will surely be great. I look forward to hearing of his rise through archaeology, which will surely be quick and distinguished. Above all, thank you for the jokes and laughter George, these make working in the field all the more enjoyable.

Finally, thanks should also go to the town of Joya de Cerén and its residents, who have proven (as always) to be patient and understanding in all aspects of day to day interaction. This made it even more of a pleasure to work with these individuals in what, for us, is a location to visit and work, but is for them their home. Thank you for having us.

Chapter 3. Platforms, Walkways & Other Cleared Areas.

George O. Maloof

Introduction

Since the mid 20th century, Classic Maya agriculture has been traditionally characterized as having been highly organized with a significant level of intensification in order to be able to support the large populations living in the big centers (Abrams 1995; Sheets et al. 2007). Even at a more local level, the populations of Middle Classic Period sites in and around the Zapotitán Valley were sufficiently large to require a more intensive agricultural strategy than would be normally needed to support village level sustenance (Black 1983).

During the 2009 field season, ample evidence was found to support the use of an intensive agricultural strategy by the Middle Classic Period residents of Joya de Cerén. However, several of the operations excavated lacked evidence of intensive cultivation. These operations were generally located on the hill overlooking the project area where the angle of the slope was at its greatest, although one was located near the edge of the secondary river terrace to the southeast of the main group of excavations (Figures 3-1 and 3-2). The lack of active cultivation in these areas suggests that the level of cultivation was not geared to maximize every available cultivatable space, which might indicate that the pressure for production on the residents of Middle Classic Period Joya de Cerén was not very high (Christine Dixon, personal communication, 2009).

Figure 3-1. Hill overlooking the project area where evidence of cleared areas was encountered. The Middle Classic Period Joya de Cerén village is to the right past the wooded area. (Photograph by Payson Sheets).

Furthermore, with the great quantity of agricultural products that would have been harvested from the manioc (Manihot esculenta) and maize (Zea mays) cultivation plots, areas for the processing of these harvested cultigens would have been an important concern to the Maya agriculturalists working in these fields.

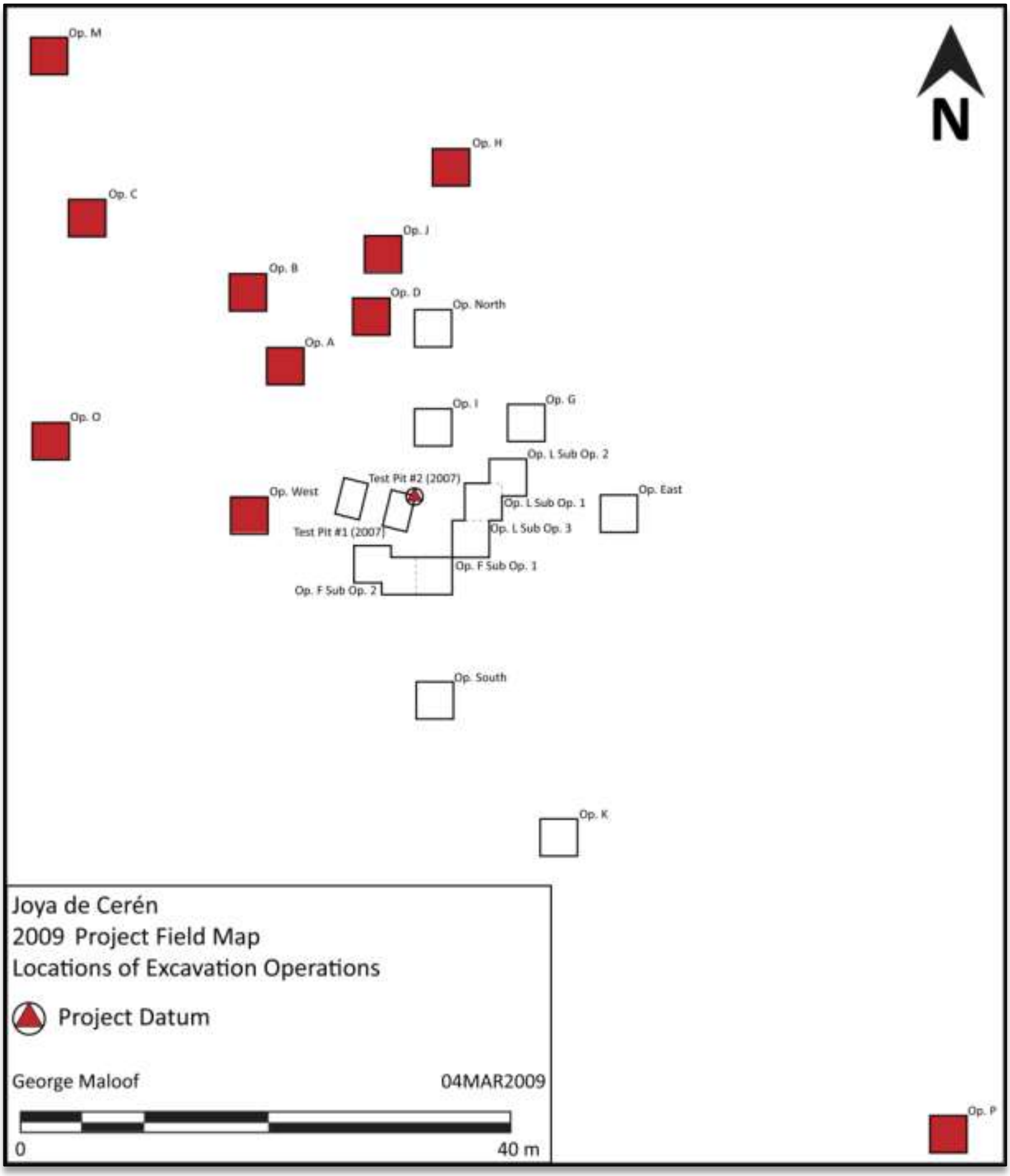

Figure 3-2. Map of the 2009 project area showing the excavated operations. The operations discussed in this chapter are marked in red.

Operation West

Operation West was one of the first four excavations conducted during the 2009 field season (Figure 3-3).The northwest corner of this operation was located 15 meters west of the established project datum, which was the northeast corner of Test Pit 1 from the 2007 field season, situated above the point of inflection of the hill to the west of the project area. The location of these first four excavations was based upon the idea of radiating out from the test pits from 2007 in the hope of finding an area of un-harvested manioc beds. The slope of the modern hill, coupled with the fact that the pit was excavated in an area that has suffered a greater amount of surface erosion, resulted in Operation West measuring a little more than two meters deep to the *Tierra Blanca Joven* (henceforth TBJ) surface, the Middle Classic Period living surface. At the surface of the Unit 3 volcanic ash layer, a seismic fissure was encountered that would later also be detected in Operation B, however, its presence was minimal and it did not seem to have affected the Middle Classic Period living surface in this area.

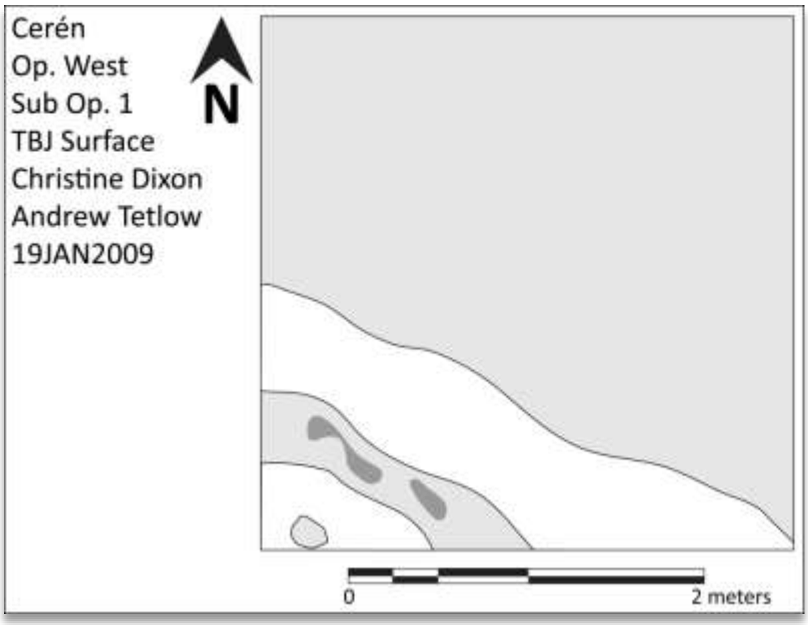

Figure 3-3. Map of the Middle Classic Period occupational surface of Operation West.

Excavation here revealed remnants of long abandoned agricultural ridges in an area kept relatively clean of extraneous vegetation. The average surface slope of the TBJ in this region was four degrees. Although several plant cavity clusters were poured and excavated from this operation, the majority of them seem to have either been from isolated tree branches that apparently were blown into the area by the Loma Caldera eruption or the roots of more recent vegetation that had penetrated into the lower units of the deposited tephra. No evidence was identified in the operation of purposeful cultivation that would have dated to the period immediately leading up to the eruption.

Operation A

The northwest corner of Operation A was located 12 meters north and nine meters west of the project datum. Test Pits 3 and 4 from the 2007 field season, located on the top of the hill in this region, had also revealed a cleared area (Blanford 2007). The location of Operation A, along with Operations B and C, was selected as a test to determine if the open space of Operation West was an isolated surface feature or if it was a larger pattern where cultivation was not being conducted higher on the hill.

Excavations of Operation A revealed another area of highly eroded agricultural ridges with an average slop of eight degrees. These ridges roughly correspond with the size and orientation of manioc surcos found in this region and could have been manioc surcos left fallow long enough to be almost imperceptible. Although there was no evidence of deliberately controlled cultivation, several plant cavities that may be manioc roots and tubers were found both on the Middle Classic living surface as well as directly below it (approximately 33% of the cavities were above the surface) (Figure 3-4, Clusters 1, 3 and 4). These manioc plants could be considered volunteers, as there is no evidence of purposeful planting, however, these could likely be the remains of earlier manioc cultivation in the region. Beyond the manioc plants, there was evidence of other types of vegetation; however, the surface was kept reasonably clean within the area of the operation.

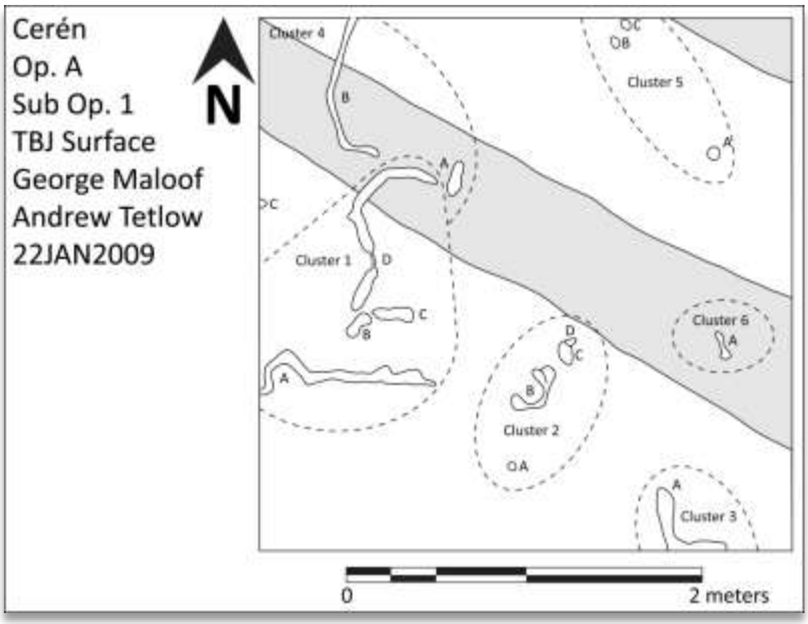

Figure 3-4. Map of the Middle Classic Period occupational surface of Operation A showing the locations of the various plant casts.

Operation B

The northwest corner of Operation B was located 15 meters north and 12 meters west of the project datum, to the northwest and slightly higher up the western hill than Operation A. Excavations at this locale revealed a cleared, leveled area (average of eight degrees) with an almost complete absence of plant remains on the living surface. An important feature of this operation is that during the Loma Caldera eruption, there was a large earthquake sometime immediately after the deposition of Unit 3, causing a fissure and a vertical displacement of the ground surface of at least 20 cm (Figure 3-5). A probable product of the fissure was a very large cavity that was found in the northwest corner of the operation (Cluster 3). This cavity received 50 pounds of plaster and still failed to be completely filled. Once excavated, it was decided that it had probably been created by the earthquake and subsequent fissure and was not the result of plant decay (Payson Sheets, personal communication, 2009).

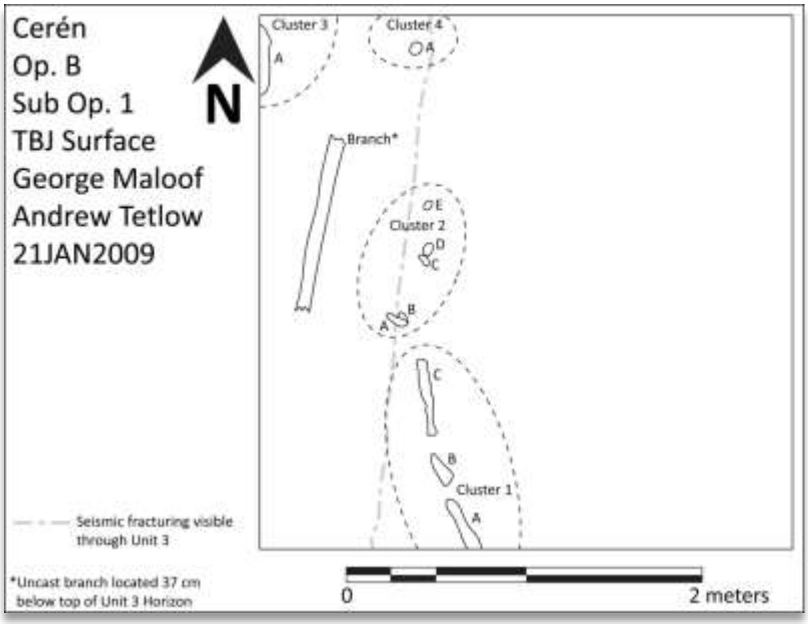

Figure 3-5. Map of the Middle Classic Period occupational surface of Operation B showing the vegetation cast clusters and the seismic fracture.

Operation C

The northwest corner of Operation C was located 24 meters north and 28 meters west of the project datum, about 15 meters west northwest of Operation B. This operation revealed evidence of low, heavily eroded ridges throughout most of the excavation towards the northeast end that were nearly imperceptible, a clear indication that they had not been cultivated in some time (Figure 3-6). The spacing of the ridges of approximately one meter coupled with the naturally good drainage of this area of the site (average slope of nine degrees), however, indicates that they had probably been used to cultivate manioc.

This operation only contained one single plant cavity, in the southern half of the test pit near the western wall (Cluster 1), which corresponds to a 10 centimeter long probable manioc stalk fragment identified by the growth node about 4 cm from the lower end (David Lentz, personal communication, 2009) (Figure 3-7). The singular nature of this plant indicates that it had probably sprouted as a volunteer and had not been purposely planted. Furthermore, the presence of a manioc plant at this locale gives further evidence that manioc had indeed been cultivated here and then subsequently been abandoned at some point prior to the eruption of the Loma Caldera volcano.

Operation D

The northwest corner of Operation D was located 16 meters north and four meters west of the project datum. The placement of this operation was decided based on the results of the excavation of Operation North. In order to place the test pit, the southern-most furrow in Operation North was extrapolated up-hill at a distance of two meters to the west. Along with Operations H and J, Operation D revealed the upper end of the manioc planting beds that were found in the majority of the rest of the operations excavated during the field season. In all three of the mentioned cases, the northwest portions of these excavations were areas that were leveled and intentionally kept clear of extraneous vegetation. In the case of operation D, roughly half of the excavated area was found to be part of the cleared, more leveled platform (Figure 3-8). In Operation D, the slope of the platform measured only three degrees while the area of the manioc ridges measured an average of 10 degrees.

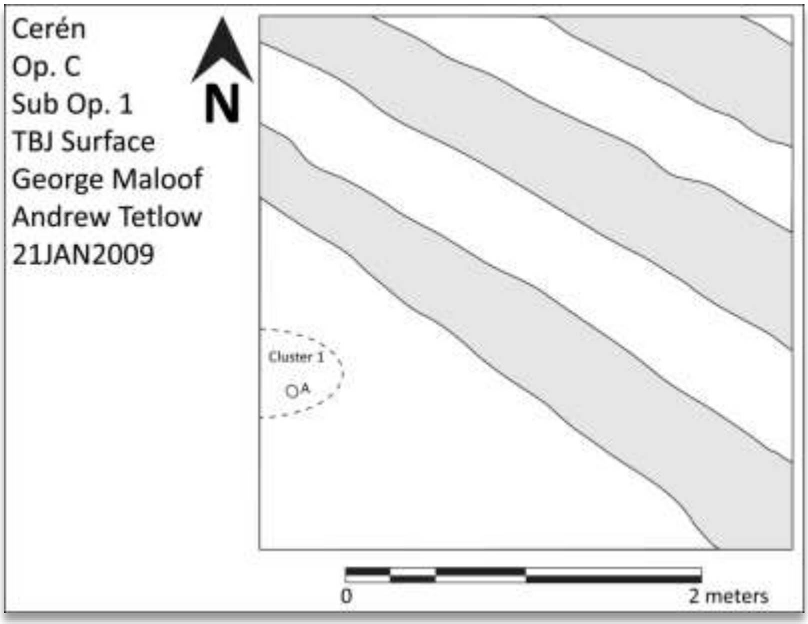

Figure 3-6. Map of the Middle Classic Period occupational surface of Operation C.

Figure 3-7. Plant cast C1A1 that has been interpreted as a probable manioc (Manihot esculenta) stalk fragment. Note the growth node near the center (Photograph by Payson Sheets).

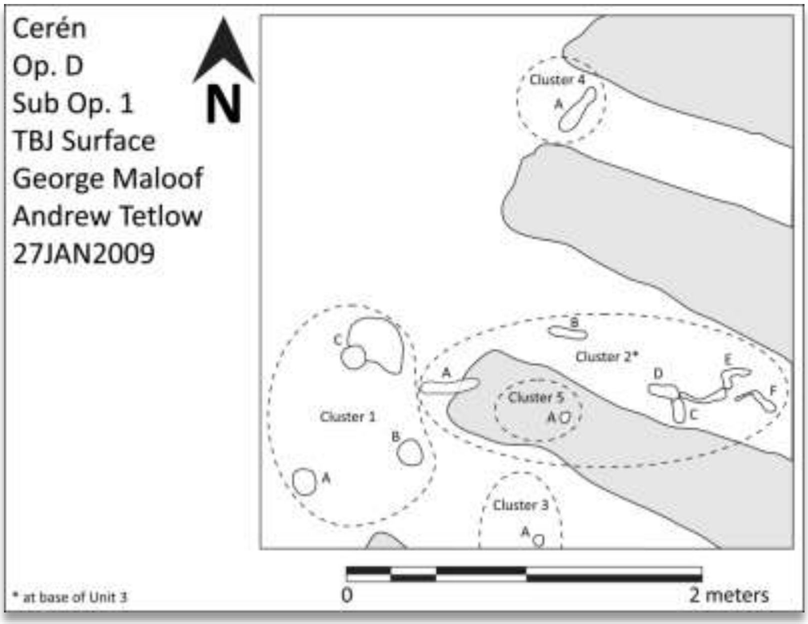

Figure 3-8. Map of the Middle Classic Period occupational surface of Operation D.

Although several plant cavities were found within the ridges, only three were found within the area of the platform area (Cluster 1). As can be seen in figure 3-8, the three cavities form a triangle just above the beginning of the manioc ridges. These three plants were possibly the remains of a tree that had been cut down in the center of the triangle at an earlier time and then had since begun to re-grow in this form (David Lentz, personal communication, 2009) (Figure 3-9). The fact that they did not preserve higher within the Loma Caldera tephra indicates that they maybe had been cut down once again not long before the eruption buried them. The other clusters within this operation probably are manioc remains and are described in detail in Chapter 4.

Operation H

The northwest corner of Operation H was located 28 meters north and 1.5 meters east of the project datum. The location of this operation was selected by extrapolating the line made by the ends of the ridges approximately 10 meters to the northeast of Operation D. In the case of this operation, the platform occupied only the very corner of the excavated area (Figure 3-10). The slope of the platform in this operation was not measurable for being such a small area of exposure, while the manioc ridges measured 10 degrees. Although several plant cavities were found in the operation, none were found in the area of the platform. The plant remains recovered from this operation are discussed in Chapter 6.

Operation J

The northwest corner of Operation J was located 21 meters north and four meters west of the project datum. The location of this operation was selected by projecting the same plane made by the beginning of the ridges to the southwest and selecting a point slightly beyond the mid-point between Operation D and Operation H. In this case the platform took up the majority of the excavated area save the southern half of the east wall (Figure 3-11).

Figure 3-9. Plant casts from Cluster 1; top: plant cast D1A1, center: plant cast D1B1, bottom: plant cast D1C1. (Photographs by Payson Sheets).

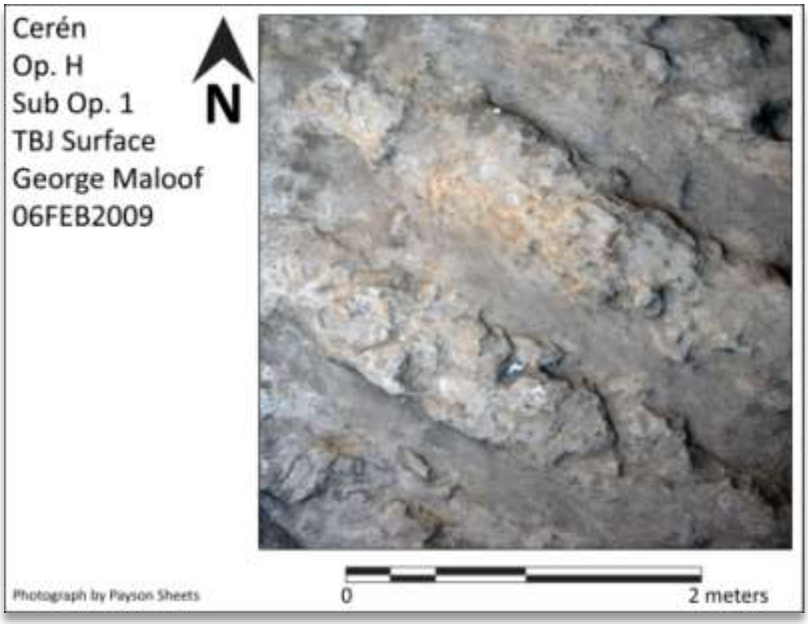

Figure 3-10. Photographic map of the Middle Classic Period occupational surface of Operation H.

Operation J was completely devoid of plant remains on the platform area, indicating a carefully maintained surface. The platform did, however, show evidence of long-abandoned and subsequently leveled out ridges of probable manioc size. The slope of the platform, 7.5 degrees, was significantly different than that of the manioc ridges that had been in use at the time of the eruption, 12 degrees.

The intersection of the platform and the beginning of the ridges revealed an area of substantial wear, evidently from foot traffic. This area had an east-west slope of five degrees and a north-south slope of three degrees. The presence of this high traffic region is logical given that the beginning of the ridges would have been the most obvious place to walk across the area in order to access the individual furrows, minimizing the risk of damaging the ridges or cultigens within them.

Operation M

Operation M was the northwesternmost excavation conducted during the 2009 field season. The operation was located 37 meters north and 31 meters west of the project datum. The location of this operation was selected to evaluate an area further from the central excavations of this field season. It was hypothesized that the location of Operation M would document the northern extent of open space area identified in the other operations along this hill slope. Located on a steeper portion of the hill overlooking the project area, the operation revealed a well maintained, uncultivated area with little plant remains readily visible. The most interesting feature of the operation, however, was a possible footpath that crossed the westernmost edge of the excavation (Figure 3-12). The foot path followed a trajectory of roughly 15 degrees east of magnetic north toward the archaeological site and appeared to continue to the southwest. As other structures have been reported in the area outside of the limits of the archaeological park by residents of the modern Joya de Cerén village, this foot path might have connected additional house clusters with the principal center of Cerén, as well as facilitated movement throughout the fields of this region.

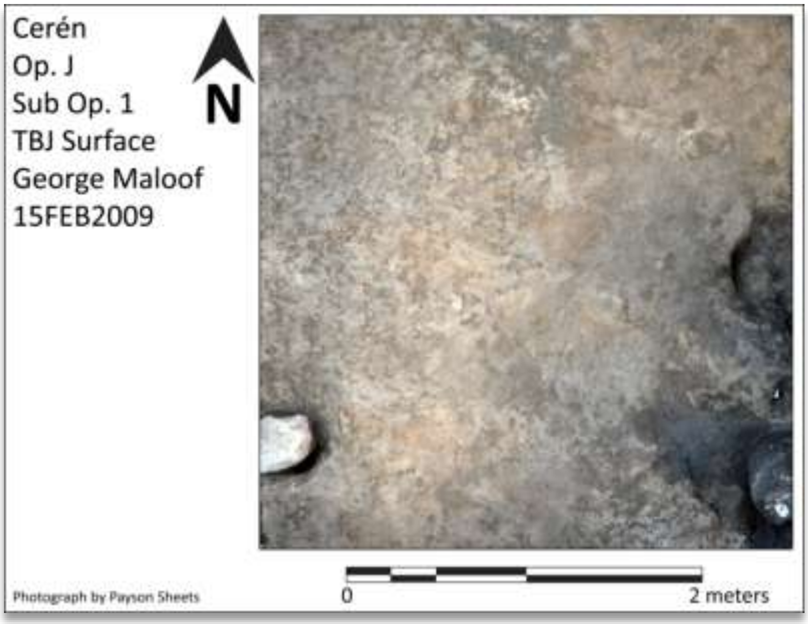

Figure 3-11. Photographic map of the Middle Classic Period occupational surface of Operation J.

Figure 3-12. Photographic map of the Middle Classic Period occupational surface of Operation M showing the location of the possible foot path.

Three plant clusters were identified within Operation M. Two clusters represented larger plant remains, possibly some sort of tree trunks (Clusters 1 and 2) and the third was a thinner stalk with not enough recognizable traits to allow for plant species identification (Figure 3-13).

Figure 3-13. Unidentified plant cast M1A3 from Cluster 3.
(Photograph by Payson Sheets).

Operation O

The northwest corner of Operation O was located six meters north and 31 meters west of the project datum. This operation contained trampled but recognizable ridges that were in much better condition than the ones found in the other operations with identifiable open space (Figure 3-14). In addition, a small number of maize plants were found to have been growing, probably as volunteers. Data indicate that this area had been in cultivation and subsequently abandoned much more recently than any of the other abandoned fields encountered during this field season.

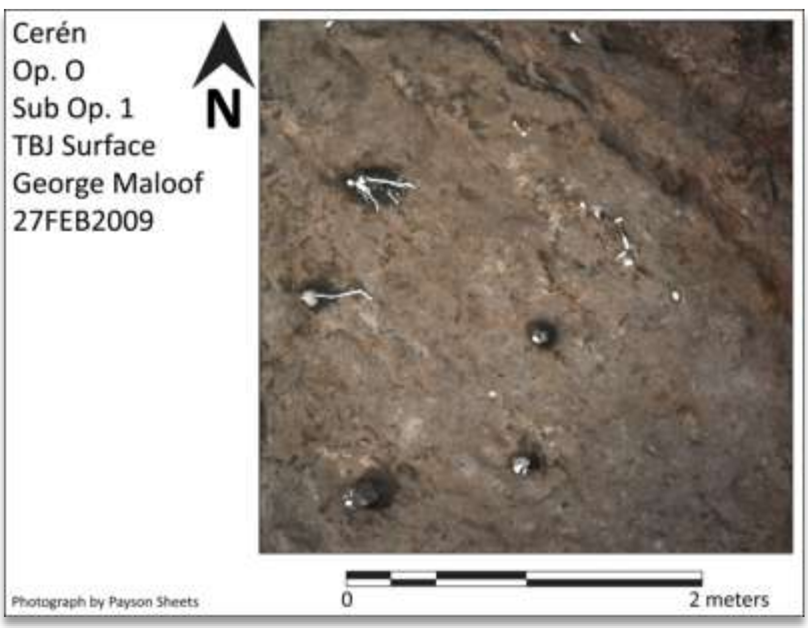

Figure 3-14. Photographic map of the Middle Classic Period occupational surface of Operation O. Stark white areas throughout the operation are dental plaster pour holes and over-runs.

Operation P

The northwest corner of Operation P was located 54 meters south and 41.5 meters east of the project datum. This operation, which was the farthest from the area of concentration, was excavated in order to characterize the lowest area of the upper river terrace and to see if the large manioc ridges continued out to this point. Excavation of the operation revealed an area that had been maintained relatively clear of vegetation as well as a carefully leveled space in the southwest corner, with the exposed area measuring approximately 1.5 meters by 0.75 meters, and the northernmost edge oriented roughly 120 degrees (Figure 3-15). This orientation is almost exactly perpendicular to the general orientation of the majority of the domestic structures, cultivation ridges within the archaeological site and the river course of the Río Sucio, which is at 30 degrees east of north (Payson Sheets, personal communication, 2009). Along the southeast edge of the level area was a large, squared-off mass of clay-rich pre-TBJ soil found to be lying on top of the TBJ surface. This mass was probably at one time formed into a type of clay block or pillar and may have acted as a field boundary marker. Given that this feature had not been maintained upright and had been allowed to slowly melt away downhill, it seems that by the time of the Loma Caldera eruption this clay mass might no longer been an important feature.

Various cavities, mostly clustered along the edge of the leveled space, were encountered that correspond to both roots as well as above ground stalks. Of these cavities, two that were located adjacent to the platform area were identified as manioc (Clusters 3-2 and 3-5). Additionally, a maize plant was identified near the northwest corner of the operation (Cluster 4) (David Lentz, personal communication, 2009). All of these plants are considered volunteers for the lack of any evidence of deliberate cultivation.

Figure 3-15. Photographic map of the Middle Classic Period occupational surface showing the location of the leveled area and the possible field marker.

Upon excavation into the living surface, it was found that both the platform as well as the surrounding area had been intentionally coated by a layer of TBJ tephra approximately six centimeters thick. Continuing excavation into this surface revealed the presence of a shallow trash midden rich in organic remains, which covered approximately three-quarters of the test pit floor towards the west and appeared to continue beyond the northern, southern and western walls (Figure 3-16). As well as an abundance of charcoal and other carbonized remains, the midden contained an unusually large quantity of carbonized beans, both of the common (Phaseolus vulgares) and lima bean (Phaseolus lunatus) varieties, as well as some maize kernels (Zea mays) (Figure 3-17) and even a possible squash rind (Cucurbita moschata) (David Lentz, personal communication, 2009). The organic contents of the midden are discussed in Chapter 6 of this report as well as in the final botanical report following the completion of laboratory analysis. In addition to the rich botanical remains encountered, a large sample of cultural artifacts, including ceramic sherds and lithic tools, were recovered and are more fully discussed in Chapter 5.

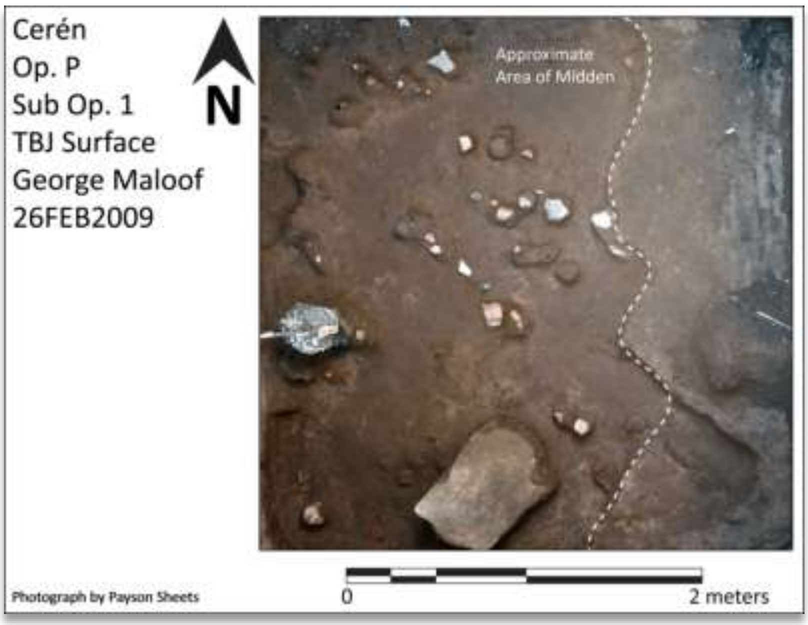

Figure 3-16. Photographic map of the excavated midden of Operation P.

Discussion

At the height of the Classic Period, the big Maya centers contained very large populations. Even at a more local level, the Classic Period population levels of the Zapotitán Valley, as estimated by Black (1983; 82), reached as high as 100,000 people (180 persons per km^2). Arguments have been made for the centrality of maize to sustaining large populations despite the lack of scientific evidence demonstrating milpa would not be sufficient to feed these multitudes (Sheets et al. 2007). Although this "fact" has been challenged by the idea of manioc cultivation (Sheets et al. 2007), there exists some problems that need to addressed.

As once manioc has been harvested it only has a maximum use-life of two to three days (Payson Sheets, personal communication, 2009), a method of processing and storage must be considered that would be able to maximize the amount of time that it could be used as a viable

Figure 3-17. Examples of some of the carbonized plant remains recovered from the midden of Operation P; left: common beans (Phaseolus vulgares); center: lima bean (Phaseolus lunatus); right; maize kernel (Zea mays). (Photograph by Payson Sheets).

food source. Although in certain areas of South America whole tubers are stored in grass-lined storage pits (David Lentz, personal communication, 2009), no evidence of this practice has thus far been found either within the village or in the area of cultivation (Payson Sheets, personal communication, 2009). As has been discussed elsewhere in this report (Chapters 4 and 8), the most readily acceptable alternative processing method would have been to remove the cortex, dry the tubers, and then grind them into a type of flour, known locally as *almidón*. In order to be able to prepare and process the tremendous quantity of manioc that would have been harvested from the area of cultivation, large, well maintained, open areas adequate for processing and drying would have been needed.

The data collected during the 2009 field season indicate that no active cultivation had been taking place on the steeper part of the hill above the upper manioc beds at the time of the Loma Caldera eruption. Evidence from test pits excavated during the 2007 field season at the top of the hill gives further evidence that no cultivation was taking place in this area nor had it been done here for some time (Blanford 2007). Furthermore, information obtained from many of the test pits indicate that large areas had been carefully maintained clean and cleared of extraneous vegetation. Finally, evidence from the 2007 field season revealed another possible platform to the north of this cultivation area very close to the site proper (Dixon 2007). Thus, it is likely the operations discussed in this chapter with expansive, cleared areas in the immediate vicinity of the cultivation fields would have been used for drying tubers in preparation for the grinding process. Furthermore, this area would be more ideal for drying and less ideal for cultivation due to it being the steepest portion of the hill. Finally, in the excavation of Operation P additional evidence for manioc processing might have been identified in the form of a manioc tool kit (Chapter 5).

Several of the operations that revealed cleared areas also showed evidence of prior cultivation. These areas had been under cultivation at some point prior to the Loma Caldera eruption but had been purposely abandoned and prepared for another activity. The conscious decision to not use these areas indicates that the pressure for food production was not great and the cultivators could afford the luxury of leaving these marginal areas out of production (Christine Dixon, personal communication, 2009).

Conclusion

The research into Maya agricultural practices at Joya de Cerén is just beginning. In order to better characterize the activities that were taking place on the eve of the Loma Caldera eruption further investigation must be carried out. The best method for covering the maximum amount of area in the least amount of time is ground-penetrating radar. This process was already begun in the 2007 field season (Guerra 2007) and should be continued on a much grander scale, with continued work to identify agricultural fields in the radar imagery (Dixon 2006). These surveys coupled with complementary excavations are needed in order to be able to obtain a clearer picture as to how big of an area would have been reserved for alternative activities as well as to why these areas were not under cultivation at the time that the site was rapidly abandoned.

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Ch. 4. Manioc Agriculture

Christine C. Dixon

Introduction

The exceptional preservation of the Classic Period Cerén village has afforded great insights into the quotidian practices of commoner lives. As extraordinary as the preservation of kitchens, domiciles, and specialized structures are the preservation of agricultural remains. Typical taphonomic processes result in the erosion and deterioration of agricultural fields and plant remains of most sites. Thus, a lack of preservation has limited archaeological knowledge of Classic Period (A.D. 300-900) Maya agriculture to mainly botanical remains, iconographic representations that highlight the seminal role of maize, and soil productivity estimates (Fedick 1996; Lentz and Ramirez-Sosa 2002; Sharer 2006). Remarkably, the Loma Caldera eruption has captured agricultural fields of the Cerén village almost intact as they were on the day the volcano erupted approximately 1400 years ago (Sheets 2002).

Two 2 x 3 meter test pits, Test Pits 1 and 2, of the 2007 Cerén field season yielded important documentation of constructed *yuca* (manioc, Manahot esculenta) beds in the area south of the Cerén archaeological site (Dixon 2007). Earlier excavation of the Cerén center first documented the presence of manioc in the northernmost ridge of the Household 1 kitchen garden (Lentz et al. 1996; Lentz and Ramirez-Sosa 2002; Sheets 2002, 2006; Sheets and Woodward 2002: 189). Evidence such as this led to the hypothesis that manioc was a minimal part of ancient village agricultural production, likely a mere supplement to the predominant stables of maize, beans, and squash (Sheets 2002, 2006). Thus the principal hypothesis for the use of yuca at Cerén was production for consumption, whereby yuca was used as a supplementation to the diet and, similar to traditional agricultural practices in the area, it was expected villagers would have dug up a manioc tuber as it was needed by the household. The manioc beds of 2007 demonstrated that perhaps more manioc was being produced and it had a larger role in the diet of villagers than previously thought. The 2009 field season was organized around the manioc beds discovered in 2007 with the aim of placing these beds in a wider context by investigating the surrounding region. We expected to find pre-harvest manioc nearby, which would facilitate a detailed estimate of manioc productivity in this area. Instead, the 2009 field season yielded a never before seen glimpse into the broader organization, the variation in cultivation, and importance of manioc at Cerén and in the Maya area.

Background

Importance of manioc to the Maya:

Prior to the mid-twentieth century, most scholars subscribed to a view of the Classic Period Maya as dispersed populations dependent on *swidden* (slash-and-burn) cultivation of maize, and the secondary crops of beans and squash (Gann and Thompson 1931; Harrison and Turner 1978; Turner 1978; Sanders 1973; Sharer 1994). There were few evidentiary challenges to reconstructions of Classic Maya society as similar to the dispersed populations witnessed during the Contact Period, thus, swidden agriculture remained the dominant model for Maya subsistence for many years (Dunning and Beach 2004). When researchers, in particular the Tikal archaeological project, identified dense populations within the Maya area, of likely hundreds of people per square kilometer, archaeologists began to question how such large populations could have been sustained (Culbert and Rice 1990; Haviland 1965, 1972; Sharer 2006). As Webster has stated, “if even the lower figure of 100 per sq km…is accurate in order of magnitude terms, which seems likely, it much exceeds the capacity of long fallow swidden cultivation” (Webster 2002: 174). The mid-twentieth century witnessed an upsurge in research concentrating on the potential types of intensifying systems that could have been utilized in pre-Hispanic Maya subsistence such as: continuous field cultivation or high performance milpa, kitchen gardens, arboriculture, hydraulic modifications, and root crops (Bronson 1966; Sharer 2006). One answer championed by Bennet Bronson was that the Classic Maya relied on root crops, in particular manioc. Bronson argued that seven out of ten ethnographically recorded Maya groups cultivated manioc (1966), one of which was the closest Maya group to Cerén today, the Chorti (Sheets et al. 2007). Among the Chorti Maya manioc has been recorded growing in fields separate from other crops (Wisdom 1940: 56). Furthermore, Bronson cited the linguistic presence of the word manioc (*tz-iXn*) in most major branches of Mayan languages and argued this might indicate the widespread presence of manioc in the past (1966). Bronson’s work ignited widespread discussion of alternatives to maize production and in particular the role of root crops in Classic Period Maya subsistence. Unfortunately, a lack of archaeological evidence for root crops has limited the traction of this argument.

Lack of evidence for manioc:

The manioc debates of the mid-twentieth century have fallen quiet in recent literature and the role of root crops in the Maya past has remained largely uncertain (Crane 1996). At the height of such debates, Kent Flannery criticized scholars who, “believe on faith [in Pre-Columbian manioc cultivation] because there is no archaeological evidence to support it” (Flannery 1982: xix). Current work is beginning to document evidentiary support for the presence of manioc in the Maya area. For example manioc pollen and phytoliths of manioc cultivation recently utilized in this region (Balter 2007). Pollen of what is most likely domesticated manioc was found in swamp cores taken in Northern Belize. These cores were dated to approximately 3400 BC (Pohl et al. 1996). Moreover, our recent findings at Cerén provide just such corroborative support of the presence of manioc in Classic Period cultivation by documenting manioc planting beds, as well as, plaster casts of tubers, stalks, and roots.

2007 Findings- Test Pits 1 and 2

The fieldworkers, local farmers, our research team, and later agricultural engineers of nearby CENTA (Centro Nacional de Technologia Agropecuaria y Forestal), an agricultural research institute, identified some of the 2007 plant casts as manioc tubers. Nagib Nassar, an authority on manioc, confirmed the identification of manioc and recognized numerous manioc stalks or trunks cut into 1 to 1.5 meter long stakes (Sheets et al. 2007). It was soon realized that the stakes had been buried horizontally, submerged within the planting beds, which is a known cultivation technique for modern manioc production (Toro and Atlee 1985). Both the manioc tubers and stalks were identified as robust in comparison to modern manioc, thus indicating that there evidently was abundant tuber production underway at the time of the eruption (Sheets et al. 2007).

A total of five manioc tubers were clearly identified in the assemblage of the plant casts excavated in 2007. Additionally, seven cut manioc stalks had been planted horizontally as stakes for the next cycle of plant growth. The low number of tubers, in correlation with the presence of stakes, indicates that harvesting had just occurred and the few remaining tubers found were likely those that broke off and were thus missed during the harvest (Sheets 2007).

2009 Objectives

The primary purpose of the 2009 field season was to locate an area of pre-harvested manioc and possibly the extent of manioc cultivation in this vicinity. Furthermore, we hoped to extend knowledge of the area immediately surrounding Test Pits 1 and 2 to document the possible size of this yuca field, patterns and variation of manioc cultivation, and potential field divisions. In the excavation of eighteen total operations this season we recorded a greater extent of careful manioc cultivation than previously recognized for the Classic Period Maya. Moreover, this project has greatly enhanced our understanding of manioc production through the documentation of field organization, the diversity of production style, the boundaries between individual field lots, and a western and eastern boundary of these manioc fields.

Research Methods

Standardized methods were applied to each of the operations excavated this season. All operations of the 2009 field season were 3 x 3 meters in size, unless otherwise specified. This size was chosen to facilitate an appropriate sample in each locus, as well as, enough room for excavators when the Op. reached two or three meters beneath the modern day ground surface. The excavation of all operations this season followed the standard methods of 2007 in that the fertile soil of the modern A-horizon was separated from the underlying tephra of the Loma Caldera eruption. Thus, upon backfilling each operation we were able to maintain the integrity of the fertile top soil and allow continued crop productivity. The A-horizon in this region was approximately 20 cm deep, light brown, and as expected in the dry season, contained very little to no moisture. Additionally, the landowners were compensated for any damage done to crops during our excavations.

Excellent stratigraphic documentation of the Loma Caldera tephra sequence has shown that the eruption occurred in a period from a few days to at most a week or two (Sheets 2002). Thus our confidence that there was no cultural reoccupation of the area during the eruption allowed us to excavate rapidly through the uppermost stratigraphy with picks and shovels. With one exception, all of the hollow cavities documented this season were encountered in or below the Unit 3 tephra. As we reached lower tephra strata excavations slowed, and hoes (*azedones*), digging sticks (chuzos), and trowels were used to excavate down to the *Tierra Blanca Joven* (TBJ) living surface of the Cerén village. Importantly the fine ash of the eruption conserves the imprints of plants that were growing above the TBJ surface at the time of the Loma Caldera eruption. Special excavation techniques have been developed for the preservation of such plant imprints. Upon encountering hollow cavities in the Loma Caldera tephra, we visually investigated each hole, sometimes with the aid of a scope to determine if the cavity is of cultural significance. These holes were plugged with newspaper to prevent loose tephra from falling in and then the area was pedastaled as excavations continue down to the TBJ surface. Lastly, dental plaster was poured into the cavities, allowed to set, and then excavated. When a cavity is well preserved in the tephra the result is an identical cast of the plant form that once occupied this void. After exposing the entire TBJ surface of an operation, and excavating any pedestaled plant casts, we created photo-maps for provenience of each plant cast within the context of the TBJ horizon (see Chapter 7). For photographs of some important plant casts we used water and toothbrushes to clean the casts *in situ* in order to enhance the contrast between the plant cast and the surrounding matrix for photography. Once documented any plant casts above the TBJ surface were removed and another photograph was taken to map and document the TBJ living surface.

The cultivation ridges and furrows of each Op. were measured for ridge height, ridge wavelength or spacing, the orientation of the fields, and the average slope of the ground surface in the Op. In the case of manioc ridges the TBJ soil preserved plant forms in a similar manner to the tephra of the Loma Caldera eruption. Thus in order to completely document the contents of each yuca bed we excavated into the TBJ surface down to the level of the *calles* (furrows), casting any hollow cavities that were encountered. This data allowed us to determine if the manioc beds had been replanted or not and provided us with casts of multiple stalks, roots, and tuber fragments. Soil samples were also taken in each operation from the TBJ soil in the manioc and maize ridges, the pre-Ilopango soil in or below the manioc or maize ridges, the TBJ surface and the pre-Ilopango soil of the calles. These samples will be employed in documenting evidence of pollen and phytoliths. Each sample was collected with a clean trowel that was washed with water between each use to minimize potential contamination. Furthermore, soil samples were collected from our excavations by engineers from CENTA (Centro Nacional de Tecnologia Agropecuaria y Forestal). These data have provided us with analysis of soil chemistry for the fields encountered during this season (see Ch. 5). Upon the arrival of our paleoethnobotanical expert Dr. David Lentz, we began collecting larger soil samples for floatation. Six liters of soil were collected from the top of the TBJ surface in Ops. F-1, L-1, L-2, L-3, M, and P. Dr. Lentz will utilize these samples to document macro and micro botanical remains of cultigens that were also present in these areas of excavation (see Ch. 6).

Our excavations at Cerén have taught us how to distinguish manioc beds and maize ridges. Maize ridges have been found throughout the Cerén village and to the south of the site center in both the 2007 and 2009 field seasons. Maize ridges generally have a wavelength of 70 to 90 cm from ridgetop to ridgetop, are approximately 10 to 15cm in height, and are hyperbolic in shape. Alternatively, the manioc beds recorded from the 2007 and 2009 field seasons south of Cerén have an approximate wavelength of 100 to 150cm (with an average for 2009 excavations of 119cm), range in height from 10 to 45cm (with an average for 2009 excavations of 25cm), and more often have been constructed with raised edges that peak in a flat top roughly 50cm wide (Figure 4-1); however, in Ops. South and K we have identified a different form of manioc bed planting that will be described in detail below.

Figure 4-1. A comparison of maize and manioc field construction at Cerén, El Salvador
Left: Maize fields from Op. East; Right: Manioc fields of Op. North.

Results of 2009 Cerén Operations Documenting Evidence of Manioc Production

We began excavations of the 2009 season by locating Test Pits 1 and 2 from 2007 in Lot 191. A total of eighteen operations were excavated this season and of these ten operations had the remains of manioc cultivation beds and three other operations documented individual manioc plant remains (Figure 4-2). The first four operations of the season were placed fifteen meters from the northeast corner of Test Pit 1 in each of the cardinal directions. These operations were

Figure 4-2. Projection of Agricultural Use Areas Identified in 2009 Field Season.

named Op. North, Op. East, Op. South, and Op. West. The excavations were placed along the terrace east of the Southern Hill and west of the Rio Sucio floodplain on Lots 191 and 192. We hoped that a standard sample of fifteen meters from the known manioc beds of 2007 would provide a better context within which to begin addressing the extent of the 2007 manioc beds, while also identifying possible field boundaries, and manioc plants that had not been harvested prior to the eruption. Instead, these first four operations revealed a great amount of variation within a very small region. Two of these operations, Op. North and Op. South, documented manioc beds and these are discussed in the following section. From these findings we began a series of operations placed in specific relationships to areas already excavated. This purposeful sampling facilitated our documentation of multiple field boundaries, a greater extent of manioc cultivation than previously recognized in the Maya world, variation in the form and style of manioc beds, and larger understanding of agricultural organization in the southern vicinity of the excavated Cerén village center. Presented here are the results of these excavations and some preliminary interpretations of these data. Further analysis of the plant casts and the macro and micro botanical remains from this season will contribute to a more detailed account of Cerén agriculture and the context of manioc production at the site.

Op. North

Operation North was one of the four operations placed in each of the cardinal directions from our datum, the northeastern corner of Test Pit 1 (Figure 1-1). Thus the northwest corner of Op. North was located 15 meters north of the northeast corner of 2007 Test Pit 1. The results of the Op. North excavation revealed portions of four manioc *surcos* (beds) and three *calles* (furrows). The surcos and calles were aligned 120 degrees east of magnetic north and had a wavelength of 105 cm from ridge top to ridge top. The average surco height in Op. North, as measured from the base of the calle to the top of the surco, was 10cm and the average calle slope was 9 degrees (Table 4-1). No hollow cavities were identified above the TBJ living surface in this Op. thereby indicating that like Test Pits 1 and 2 of 2007, the manioc in this region of the field had already been harvested.

Op	Directionality	Slope	Wavelength	Surco Height
A	117^o	8^o	110cm	6cm
C	123^o	9^o	100cm	10cm
D	119^o	3^o (level area) / 10^o (calle)	110cm	17cm
F-1	121^o	6^o	110cm,118cm	16cm, 33.5cm, 34cm
F-2	121^o	4^o	125cm	18cm
G (Maize)	115^o	7^o	70cm	11cm
G (Manioc)	120^o	5^o	114cm, 120cm	24cm
H	121^o	10^o	108cm	23cm (very irregular)
I	122^o	5^o (Upper half) 8^o (Lower half)	110cm	25cm
J	122^o	Calle: 12^o Walkway: 5^o Open space: 7.5^o	119cm	30cm
K	120^o	6^o	130cm	35cm
L-1, L-2, L-3 manioc	121^o (est. from F-1 and F-2)	unknown	117cm	22cm
L-1, L-2, L-3 maize	Unknown	7^o	74cm	10cm
North	120^o	9^o	105cm	10cm
South	124^o	6^o	155cm	45cm

Table 4-1. Description of Manioc Surcos from 2009 Cerén Excavations.

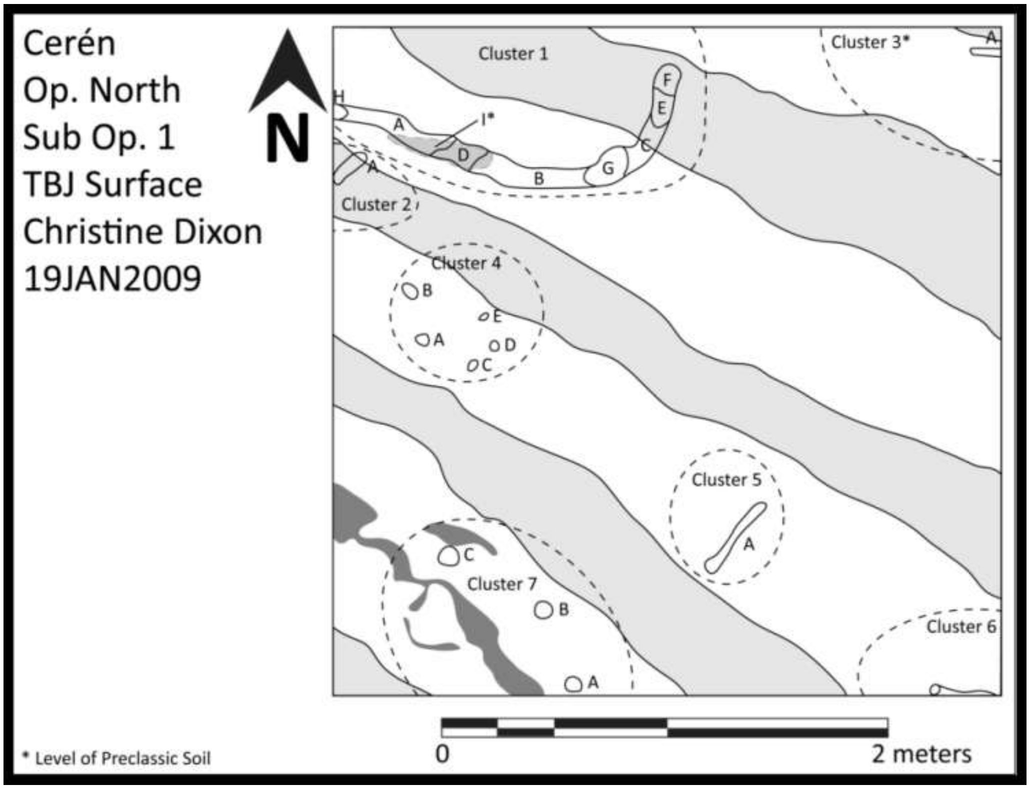

Figure 4-3. Plan View of Op. North with Plant Cluster Locations (Clusters 1-7).

The southernmost surco of Op. North had multiple depressions along the top of the ridge and appeared to be very irregular due to recent harvest before the Loma Caldera eruption. Furthermore, the plant casts recovered from within this surco (Cluster 7 A-C) were all slender and small plant casts that might be root fragments left behind during the harvest. In Op. North a total of 7 clusters (named Clusters 1-7) were identified and cast with plaster (Figure 4-3). One plant cast (Cluster 1) located 16cm above the TBJ surface was a branch blown into this location during the eruption. The other six plant cast clusters distinguished in Op. North were located within the TBJ of the manioc surcos and document manioc root fragments variable in both size and shape. These casts range in length from 3.5cm to 167cm, thus demonstrating the range of plant fragments identified in this locality. The plant casts from Op. North had an average length of 33cm, an average width of 3.6cm, and an average thickness of 2.7cm.

Op. South

Operation South was also one of the four operations established fifteen meters in each of the cardinal directions from the northeast corner of 2007 Test Pit 1 (Figure 1-1). The northwest corner of Op. South is thus fifteen meters south of the northeast corner of Test Pit 1 and is in the northern part of Lot 192. In Op. South we recorded three manioc surcos and three calles. The manioc surcos of this Op. were very large in comparison to those identified in 2007 and those observed this season. The average surco height for this Op. was approximately 45 cm from the base of the calle to the top of the surco compared with an average of 22cm in the other manioc beds recovered during the 2009 field season (excluding Ops. South and K). The shape of the surcos was also distinct in that the top of the surcos had a much narrower width and a more peaked shape. The flatpart on top of the surcos in Op. South were approximately 20 to 25 cm wide, whereas, the tops of surcos in the 2007 Test Pits 1 and 2 and in the other Ops. of the 2009 field season were approximately 50 cm wide (Figure 4-4).

Figure 4-4. A Comparison of Manioc Beds from Op. K and from Op. H. Left: Plan View of the very large, atypical manioc beds of Op. K; Right: View of typical style manioc beds from Op. H.

Thus, the surcos of Op. South had a ridgetop width of approximately half that of other manioc surcos in the region. Importantly, it is possible that this difference may be due to different construction styles by farmers and might be evidence of distinct cultivation plots or areas. The surcos of Op. South were oriented 124 degrees east of magnetic north and had a wavelength of 155 cm from ridgetop to ridgetop. This wavelength is also significantly larger than the other yuca beds of 2009, which have an average wavelength of 113cm (excluding Ops. South and K). The overall slope of the calles in Op. South was approximately 6 degrees (Table 4-1).

A total of six plant cast clusters, named Clusters 1-6, were collected from Op. South (Figure 4-5). These plant casts ranged in length from 4.3cm to 158cm. In Op. South the plant casts had an average length of 37cm, an average width of 3.8cm, and an average thickness of 2.9cm. In the northern most surco of Op. South we recorded two likely manioc root fragments that might have been left over during the harvest (Clusters 1 and 2). Similarly, in the middle surco we found one very long plant cast that is either a root that has continued growing after having been left in the ground, or a cut manioc stalk that has grown after having been replanted. This plant cast also shows evidence of re-growth in that shoots were beginning to grow off of the root at the time of the eruption.

Op. D

Op. D was placed one meter north and two meters west of Op. North (Figure 1-1). This Op. was established to examine the continuation of manioc beds found in Op. North, in particular the southernmost manioc bed of Op. North that appeared to have evidence of manioc harvesting.

Portions of four harvested and not replanted yuca beds and three partial calles were discovered in Op. D. There were many irregular depression and raised portions along the surface of the surcos which likely indicate that manioc plants and tubers were pulled up from the ground here. The manioc surcos and calles of Op. D were oriented to 119 degrees east of magnetic north and had an approximate wavelength of 110cm from ridgetop to ridgetop. The surcos were about 17cm in height from the base of the calles to the top of the ridges (Table 4-1).

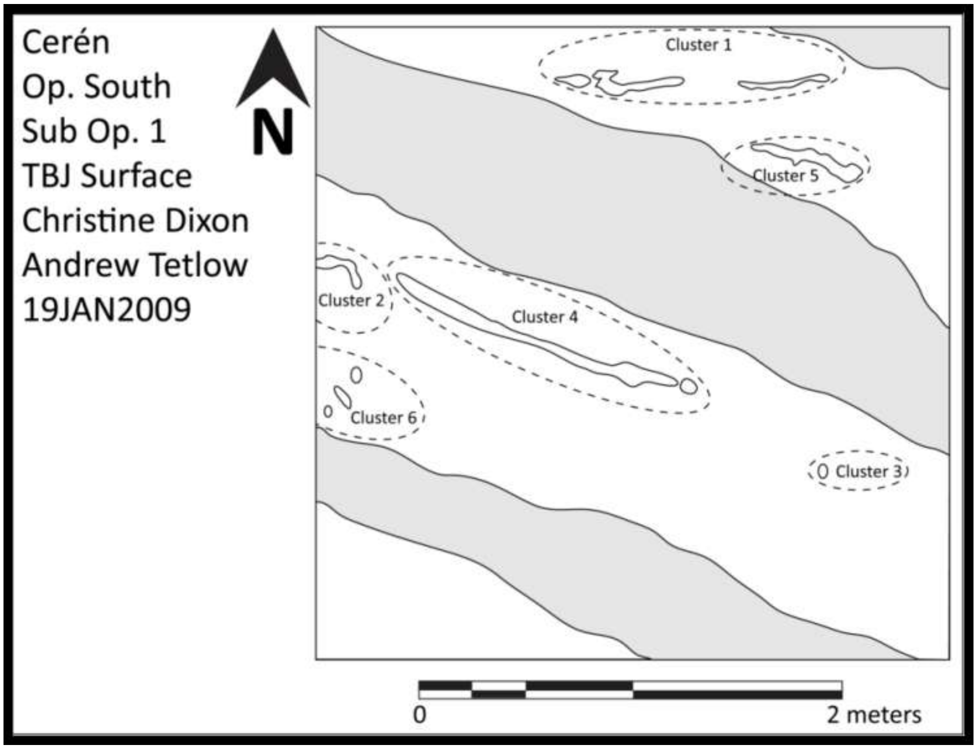

Figure 4-5. Plan View of Op. South with Plant Cluster Locations (Clusters 1-6).

Notably, Op. D provided us with our first known field boundary of the manioc fields. In the western end of the Op there was a cleared platform area, while in the eastern part of the Op. was the beginning of a manioc field (Figure 4-6). There was clearly a well organized and constructed boundary between the manioc surcos and calles and the flattened, cleared platform area in the west. This land use line affords evidence of organization and planning of manioc cultivation at the site and was oriented approximately 30 degrees east of magnetic north. The calles and surcos were aligned along this land use line and there was a steep slope of approximately 17 degrees connecting the platform level area with each calle. The depth of the calles in relationship to the flattened platform area was approximately 16 to 18cm. The leveled platform area had a slope of 1 to 3 degrees and the manioc calles had an average slope of 10 degrees. Thus, the slope of the calles would have provided excellent drainage of the platform area.

A total of five plant clusters were recorded in Op. D (Figure 3-7). These casts ranged in length from 3.5cm to 49cm. The plant cast clusters of Op. D had an average length of 24cm, an average width of 10.4cm, and an average thickness of 5.8cm. Cluster 1 recorded unique plant casts that were first encountered 10cm above the TBJ surface in the southwest corner of the Op. along the platform area west of the manioc field. These plant casts appear to be stumps from trees (Lentz 2009 personal communication). The widths of these casts were 32cm, 23.5cm, and 14cm. Dr. Lentz suggested that these might be saplings from the roots of a tree that had been previously present in the area. Such saplings could have provided shade along the platform at the western edge of the manioc field; however, given the cavities were not preserved in the upper stratigraphy of the Loma Caldera tephra sequence it seems likely these saplings might also have been cut down prior to the eruption. Plant Cluster 4 from this operation also appears to have been a possible tree root or stump given its unusual shape and size with an approximate width of 19cm (Lentz 2009 personal communication). This cast was located in the calle between the northern most and middle surcos of the manioc field just below the juncture of the manioc field and the platform area. Plant Cluster 3 of Op. D provided further evidence of a possible tree root. Cluster 3 was located in the calle between the southern-most and middle surcos of the Op. and had a width of approximately 12.2cm. The other two plant cast clusters of Op. D, Clusters 2 and 5 were located within the manioc surcos and calles and appear to be possible manioc root fragments.

Figure 4- 6. Field Boundary of Manioc and Open Space Located in Op. D.

Op. F-1, F-2

Operation F was established in the areas between Op. South and 2007 Test Pits 1 and 2 (Figure 1-1). The southwestern corner of Op. F Sub-Op 1 was positioned seven meters north of the northwest corner of Op. South. The objective of this operation was to better understand the difference in size and shape construction between the manioc beds located in Test Pits 1 and 2 of 2007 and those of Op. South. In the western part of the operation we found manioc beds oriented 121 degrees east of magnetic north. Importantly, the surcos of the manioc field in the western end of the Op. became the calles of a lower field in the east, and the calles of the manioc field in the west became the surcos of the field in the east (Figure 4-7). Thus there is a clear boundary between the upper or western field and the lower or eastern field of the operation that could have functioned as erosional control; however, it seems more likely that this distinction marks a boundary between one field and another.

The boundary between the two yuca fields is approximately perpendicular to the direction of the surcos and thus has a rough orientation of 30 degrees east of magnetic north. This orientation is very significant for the Cerén site as the household and public buildings as well as the surcos of cultigens are aligned 30 degrees east of magnetic north. Hence, the agricultural fields to the south of the excavated Cerén village appear to be well integrated with the organization of the village center. The average slope of the calles in Op. F was approximately 6 degrees in the lower field. The wavelength of the surcos in the lower field of Op. F was 110-118 cm. Interestingly, in this lower field of Op F-1, the surco height from the base of the calle to the top of the surco was variable from north to south. The northern most surco of the lower (eastern) field in Op F-1 was approximately 16cm in height, while the two surcos further south were 33.5cm and 34cm high. As will be discussed further in the description of Op. L, it is possible this is another type of field boundary between manioc and maize. We did not have enough area of the lower fields to confirm a boundary here; however, the findings from Op. L indicate that this variation in surco height might be important in distinguishing such a field boundary.

Figure 4-7. Plan view of boundary between the two manioc fields of Op. F.

The F-2 extension was an area to the west of Op. F-1. When it was originally established, the southeast corner of Op. F-2 was 2m west and 2m north of the southwest corner of Op. F-1. It was quickly decided to remove the balk between the two operations to allow for a continuous exposure of the manioc surcos in this region (Figure 1-1). We extended Op. F-2 to the west because we had located a plant cast in the western wall (towards the southwestern corner) of Op. F-1. This plant (now designated plant cast F-2-A-1) is Cluster 1 of Op. F-2 and appears to be part of a manioc stalk. Thus, it was hoped a western extension of Op. F would document pre-harvested manioc plants, however, this did not turn out to be the case. The surcos and calles of the upper field in Op. F-1 were the same of those in the F-2 extension of the Op. These manioc beds were aligned 121 degrees east of magnetic north, had an estimated wavelength ridgetop to ridgetop of 125cm, and an average height of 18cm from the base of the calle to the top of the surco. The calles in the upper field of Op. F had an average slope of 4 degrees (Table 4-1).

Four plant cast clusters were collected from Op. F-1 and these range in length from 8cm to 151cm (Figure 4-8). The plant cluster of Op. F-1 had an average length of 30cm, average width of 6.7cm, and an average thickness of 4.4cm. Plant cast F-1-F-1 is a very long root fragment (151cm in length) with some growth nodes and is a possible manioc root. Plant cast F-1-A-3 is a manioc stalk fragment that is 8cm long, 1.1 cm wide and 1.4cm thick. Cluster 3 is an example of identifiable manioc remains in our data.

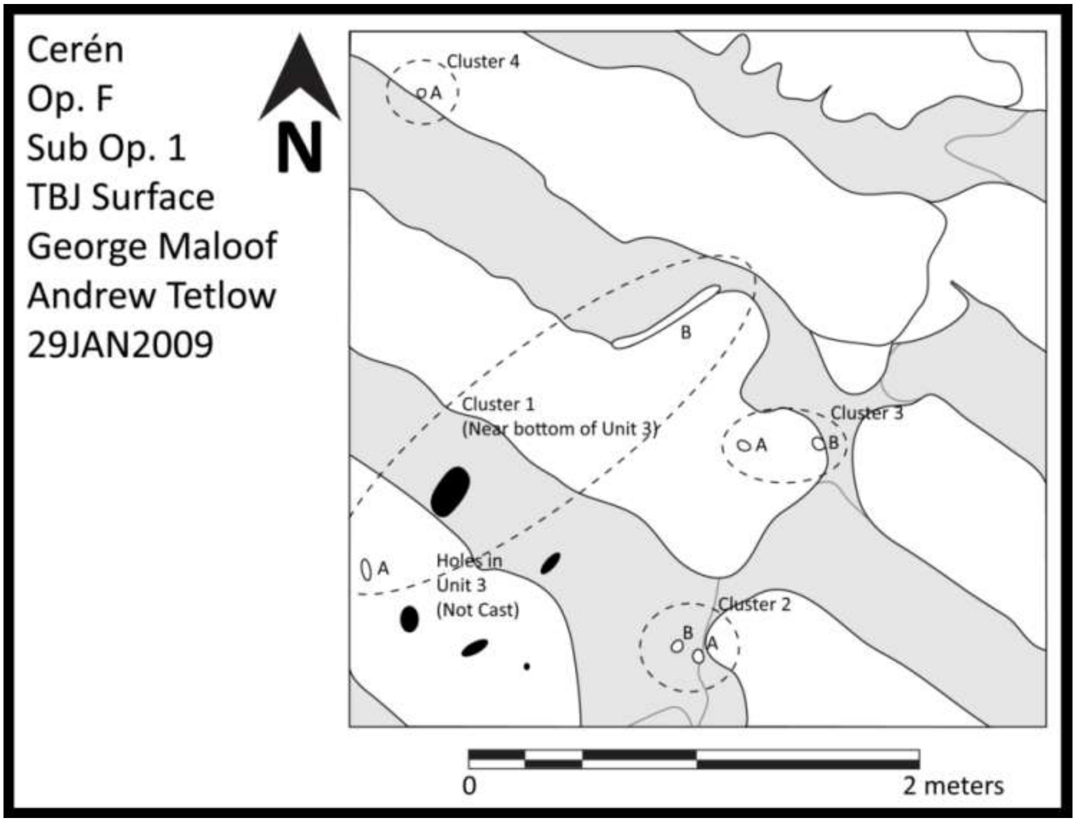

Figure 4-8. Plan View of Manioc Field in Op. F Sub-Op. 1 and Plant Cluster Locations.

In Op. F-2 there were a total of seven plant cast clusters collected and these ranged in length from 5.5cm to 460cm. Plant casts of Op. F-2 had an average length of 54cm, an average width of 5.5cm, and an average thickness of 2.9cm. In one of these clusters, Cluster 5, a weed was identified (Lentz 2009 personal communication). Cluster 1 is possibly a manioc root with growth nodes and a shoot. Op. F-2 revealed two very unusually large plant casts. Cluster 4 of Op. F-2 was 460cm in length and extended down the middle of one of the manioc ridges. This plant cast cluster had an average width of 5cm and an average thickness of 3.8cm. The cast is an example of the types of plant remains we have found that require further study. Typical manioc stakes and roots today are not this long and more research is needed to better understand why some of the casts from our 2007 and 2009 excavations are so large. The other unusual plant cluster of Op. F-2 was that of Cluster 3, which was 132cm long. This cast extended into the southern wall of the F complex and spread both horizontally and then vertically (Figure 4-9). Manioc is known to grow in a direction of least resistance. The pre-Ilopango clay below the TBJ horizon would therefore have typically discouraged any manioc root growth in this area. Interestingly, the sediment surrounding Cluster 3 was documented to be much less compacted than the surrounding areas. It appears that either a cultural or geological disturbance in the soil, before the Ilopango eruption, created a matrix which allowed the root to grow vertically below the TBJ ground surface into the pre-Ilopango sediment.

Figure 4-9. Plant Cast Cluster 3 of Op. F Sub-op. 1 extending below the TBJ horizon.

Op. G

Op. G was established between Op. North and Op. East (Figure 1-1). Given that Op. North documented manioc beds and Op. East documented maize ridges, we decided to look for the boundary of these maize and manioc fields in between the two Ops. Op. G is located 460cm west of the eastern wall of Op. North and 460cm to the south of the southeren wall of Op. North. The northwest corner of Op. East is 460cm from Op. G. Operation G was successful in identifying the eastern boundary of the manioc field encountered in Op. North and the western boundary of the maize field encountered in Op. East. There were portions of four surcos and three calles in the western part of Op. G, while in the eastern portion of the Op. there were six maize ridges and five furrows (Figure 4-10).

We had anticipated a possible break between the maize and manioc fields or perhaps a walkway between them; instead we found manioc beds in the western part of the operation that became maize ridges in the eastern part of the operation. There was no break between the two fields. The yuca surcos in this Op. had an average height of 24cm, while the maize ridges here had an average height of 11cm. Furthermore, the average wavelength of the manioc beds was 117cm, while the average wavelength for the maize ridges was 70cm. Thus, in Op. G we documented maize ridges that were approximately half the size and spacing of the manioc beds.


Figure 4-10. Plan View of Op. G Manioc Surcos and Calles, as well as, the Maize Ridges and Furrows.

The slope of the calles was approximately 5 degrees and the surcos and calles were oriented 120 degrees east of magnetic north (Table 4-1). Interestingly, the end of the manioc field and the beginning of the maize field formed a line approximately perpendicular to the directionality of the surcos and calles. The orientation of this line is about 30 degrees east of magnetic north and as previously mentioned this alignment is very important to the overall organization of Cerén structures and also agriculture.

A total of 22 plant cast clusters were recovered from Op. G. Twelve of the twenty-two clusters were associated with the manioc beds in the western end of the operation (Figure 4-11). Clusters 2, 3, 4, 5, 6, 9, 10, 16, 18, 20, 21, and 22 were all found in the western area of Op. G along the manioc surcos and calles. These casts range in length from 3.7cm to 206cm and have an average length of 37.1cm. These clusters have an average width of 5.3cm, and an average thickness of 2.8cm. Cluster 3 was recovered from the northern-most manioc calle in the Op. and is very large. Cluster 3 was a root fragment with a bulbous portion that is possibly a tuber. In total this cluster was 200cm in length, 52cm in width, and 10cm in thickness. Cluster 5 was a plant cast much wider than the others collected in this Op and is potentially a branch or large root fragment of manioc, but is difficult to identify. Cluster 5 was found in the northern-most calle of the manioc field and has a length of 56cm, a width of 11cm, and a thickness of 8cm. Also of interest is plant cast Cluster 16 which is a long and thin root fragment that is also possibly

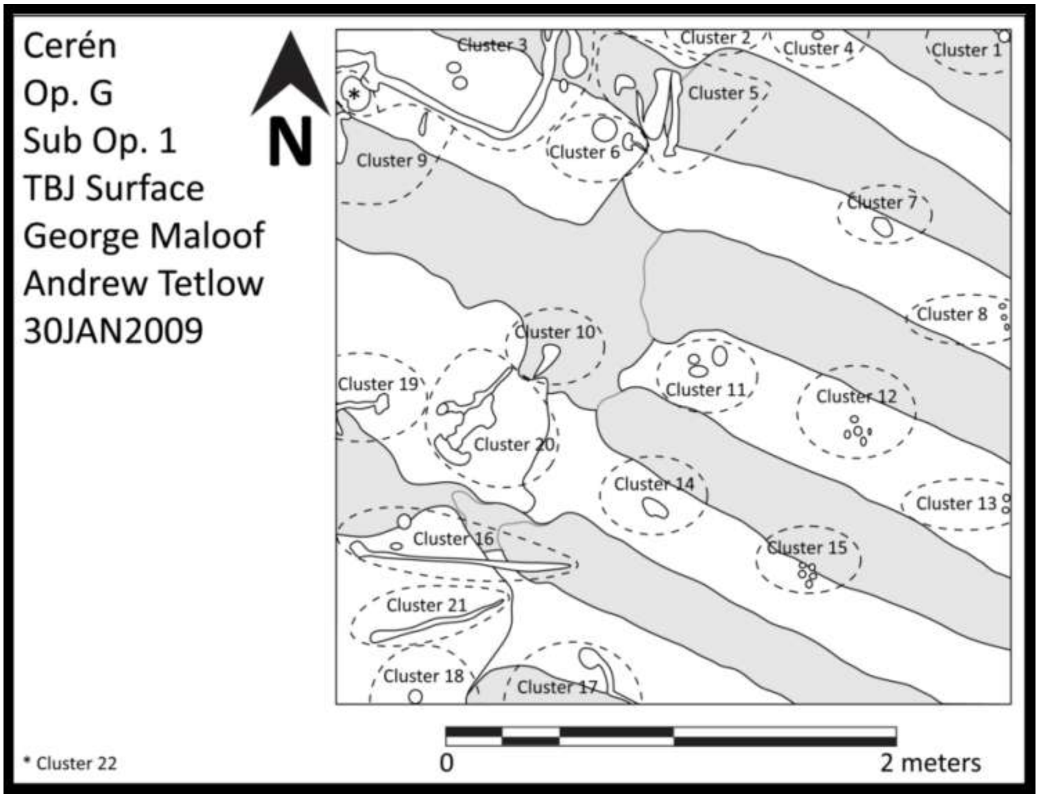

Figure 4-11. Plan View of Op. G with Plant Cluster Locations (Clusters 1-21).

manioc. This was found in the southern-most manioc surco of Op. G and was 206cm in length, 1.9cm in width, and 1.5cm in thickness. The width and thickness of this plant cast were similar to the majority of other casts from this operation, which are approximately 1-2cm. Cluster 21 was also a long thin plant cast that is 72.8cm long, 2.2 wide, and 1.2 thick. This plant cast was found in the southern-most surco of the Op. The final unusual plant cast of this Op. was Cluster 22 which was 51cm long, 15cm wide, and 11 cm thick. It is possible this is a manioc tuber and root fragment. It extended down the northern middle surco of the Op. and even extended into the northern-most calle of the manioc field. The manioc plant casts from this Op. demonstrate the unusual length of many plant cast this season, as well as, the large diversity of shapes and sizes of plant casts identified in the manioc beds. Further examination of these plant casts will aid in both identification and understanding of the variation of manioc plants from these Classic Period fields.

Op. H

The southwestern corner of Op. H was located 10m north and 1.4 m west of the northeastern corner of Op. North (Figure 1-1). Operation H was established to examine the northern extent of the manioc fields and possibly the platform found in Op. D. Hence Op. H was placed in alignment with the field boundary of Op. D. The northwestern corner of Op. H was located 1.5 meters east of the northwest corner of Op. D. Four manioc surcos and three calles were documented in Op. H, with a very small portion of two other calles present in the northeastern and southwestern corners of the Op. Furthermore, in the far northwestern corner of the operation we located a portion of a flat platform area that had an approximate orientation of 30 degrees at the top of the manioc field. This orientation is very approximate in that only a very small portion of the field boundary was present in this excavation. The yuca surcos and calles of Op. H were aligned 121 degrees east of magnetic north and had a wavelength of approximately 108cm ridgetop to ridgetop. The average height of the surcos was 23cm; however, this was very irregular in that the ridge heights ranged from 10-31cm. The average slope of the upper calles was 9 degrees, while the average slope of the calles in the eastern area was 11 degrees (Table 4-1).

A total of 6 plant cast clusters (Clusters 1-6) were recorded in Op. H and these were comparatively small for the plant casts collected this season (Figure 4-12). The lengths ranged from 4.2 to 21.1 cm, with an average length of 12.2cm, an average width of 4.6cm, and an average thickness of 2.3cm. That only a few plant casts were recovered from the surcos of Op. H fits our hypothesis that this area had been harvested but not replanted before the eruption. The top of each surco in this operation was irregular and it appears that manioc stalks and tubers might have been pulled up in these areas very recently before the Loma Caldera eruption.

Op. I

The northwest corner of Operation I was located seven meters north of the northeast corner of Test Pit 1 of 2007 (Figure 1-1). Portions of four surcos and three calles were identified in Op. I. These surcos and calles were oriented 122 degrees east of magnetic north, had a wavelength of 110cm from ridgetop to ridgetop, and had an average height of 25cm. The slope in the upper or western part of the operation was 5 degrees in the calles, while the slope in the lower part of the calles was approximately 8 degrees (Table 4-1).

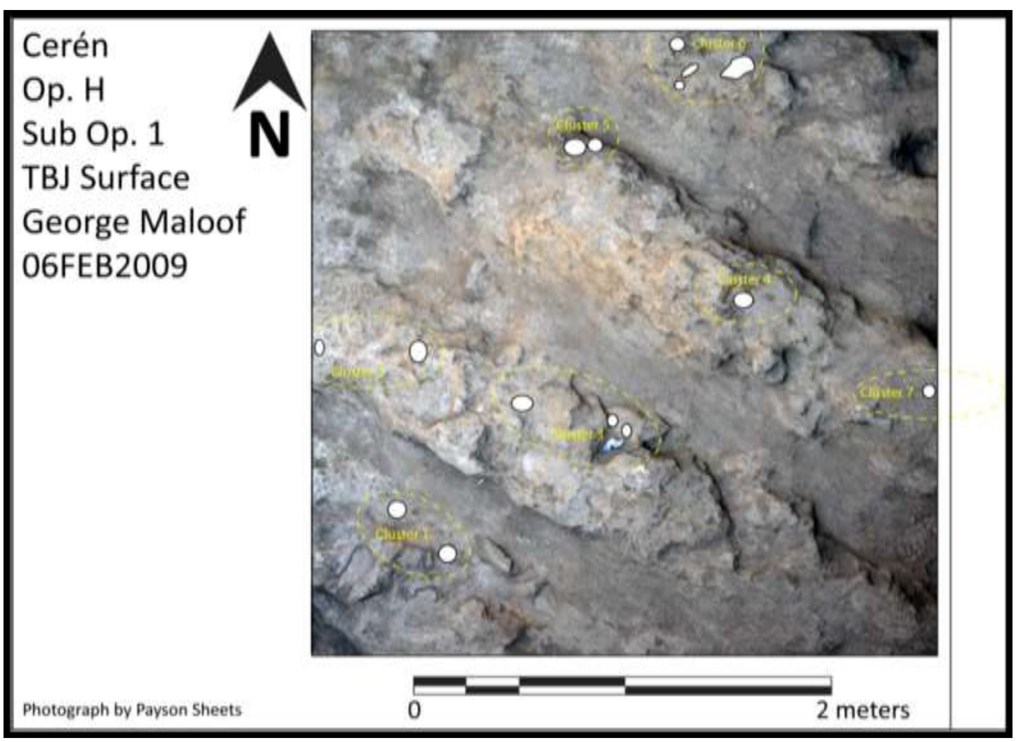

Figure 4-12. Plan View of Op. H and Plant Cluster Locations (Clusters 1-7).

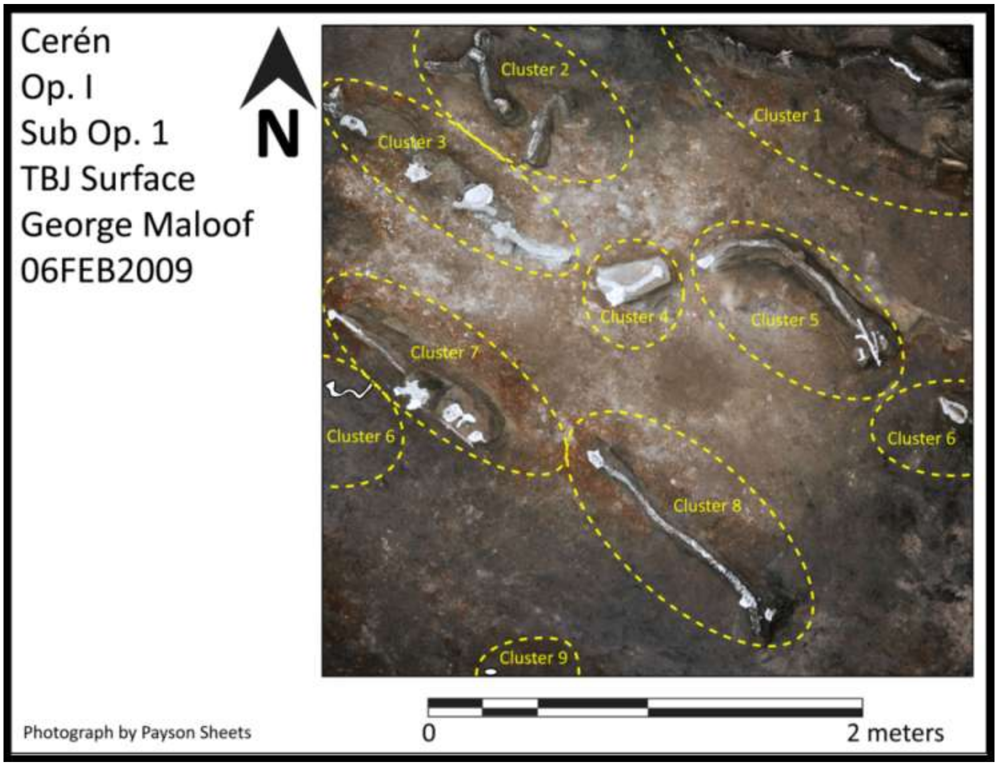

Figure 4-13. Plan View of Op. I with Plant Cluster Locations (Clusters 1-9).

Although the tops of the manioc beds were very irregular, upon excavating the surcos multiple manioc plant casts were recovered thus indicating this area might have been replanted already before the eruption. A total of 9 plant cast clusters were recovered from Op. I (Clusters 1-9) (Figure 4-13). These ranged in length from 4cm to 432cm, with an average length of 59cm, an average width of 4.5cm, and an average thickness of 2cm. Cluster 1 was 432cm in length, 4.4 in width, and 3.2 in thickness. This root was a long continuous cast of interwoven roots that extended well into the eastern wall in the northeastern corner of the operation. Cluster 1 is an example of the extremely robust root fragments and plant remains we found in the manioc beds. Cluster 6 was also a very long plant cast of 221 cm and 3.2 cm in width and thickness. Similar to Cluster 1, Cluster 6 also extended into the eastern wall of Op. I and was possibly a very large manioc root. Another likely manioc root plant cast from this operation, Cluster 5, was 78cm long and 3cm in width. This was a possible manioc root fragment that has multiple growth nodes.

Op. J

The northeastern corner of Operation J was located 4 m south and 2.6 m west of the southwestern corner of Op. H (Figure 1-1). There were two meters between the northern wall of Op. D and the southern wall of Op. J. Op J was placed between Op. D and Op. H in order to examine the continuation of the manioc fields discovered in each of these operations. Furthermore, by aligning the boundary of the manioc fields and the platform in Op. D with the small corner of a boundary between manioc fields and platform in Op. H, we were able to successfully locate this continued land use line. We had hoped Op. J would expose more of the open platform area identified in Ops. D and H because it was possible that just harvested yuca would have been placed on the platform or open space area to dry. We successfully located an area of the open space to the west of the manioc fields, with a small section of three yuca beds and four calles present in the very eastern end of the operation, and an area of high foot traffic directed west of the manioc field. Unfortunately no harvested manioc was located in this open space; however, Op. J did confirm the western boundary of the manioc fields in this region (Figure 4-14).

The manioc surcos and calles documented in Op. J were oriented 122 degrees east of magnetic north and had a wavelength of approximately 119cm from ridgetop to ridgetop. The height of these surcos was approximately 30cm and the slope of the calle was 12 degrees, the possible high traffic area was 5 degree, and the open area was approximately 7.5 degrees (Table 4-1). The end of the calles into the platform area was 7cm, 14cm, and 13cm in height. The platform area was oriented 33 degrees east of magnetic north. This measurement is approximate because of how little of the surcos and calles were exposed within the operation. It is likely that with a broader perspective of the boundary we would have a more accurate estimate of the orientation; however, given the approximate direction of 33 degrees east of north, it is likely that this boundary is an extension of the organization within the Cerén village center, as seen in the remains of other agricultural field boundaries in this region. There was one plant cast recovered from Op. J. Cluster 1 of Op. J was a root fragment that was very irregular in shape and was not identifiable as a specific plant species.

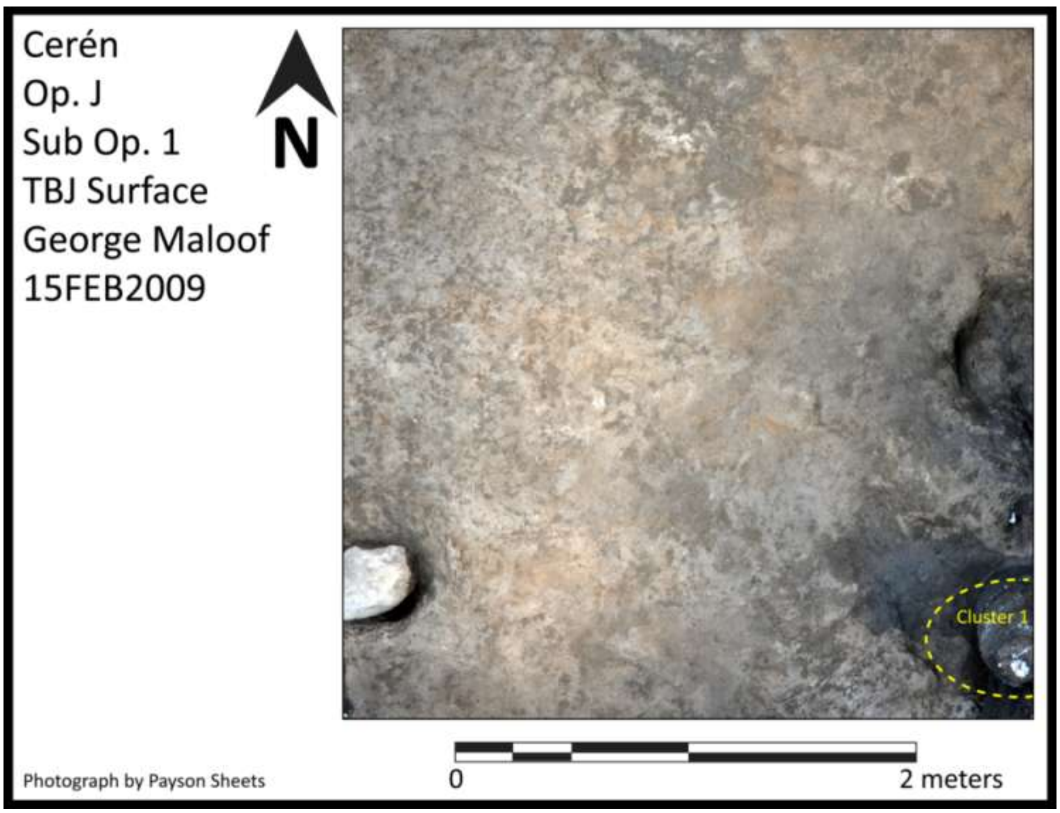

Figure 4-14. Plan View of Op. J with Plant Cluster Location (Cluster 1).

Op. K

The northeastern corner of Op. K was located 8 meters south of the southeastern corner of Op. South and 10 meters east of the southwestern corner of Op. South (Figure 1-1). This Op. was established using the orientation of manioc beds in Op. South to project the continuation of surcos and calles within this field. The primary objective of this operation was identify the eastern extent of the manioc fields in the region by documenting if manioc was also being cultivated this far east of Op. South. Aligning our excavation of Op. K with the surco orientation of Op. South allowed us to confirm if the manioc beds of Op. South continued to this distance. Op. K revealed portions of four surcos and three calles that were likely harvested and replanted, with at least one manioc plant stalk left *in situ* possibly to be harvested later in the season (Figure 4-15).

The manioc beds were oriented 120 degrees east of magnetic north, had a wavelength of approximately 130cm from ridge-top to ridge-top, and were an average of 35cm in height. The slope of the calles ranged from 5 to 7 degrees (Table 4-1). The manioc beds of Op. K were significantly larger than those of all other manioc beds identified at Cerén, other than those of Op. South. Furthermore, the construction style of the surcos and calles in this Op. varied greatly from typical manioc surcos at Cerén. The flat-top portion of the manioc surcos in Op. K were an average of 20 to 25cm wide. When compared with the more common style of manioc bed construction found in Op. F, where the flat top had an approximate width of 52cm, the flat-top portion of manioc surcos in Op. K were roughly half the width of those in other regions of our excavations (Figure 4-4). The style of the surcos and calles combined with the positioning of Op. K in alignment with surcos of Op. South indicate that these beds were connected with those of Op. South and probably were the field of the same farmer.

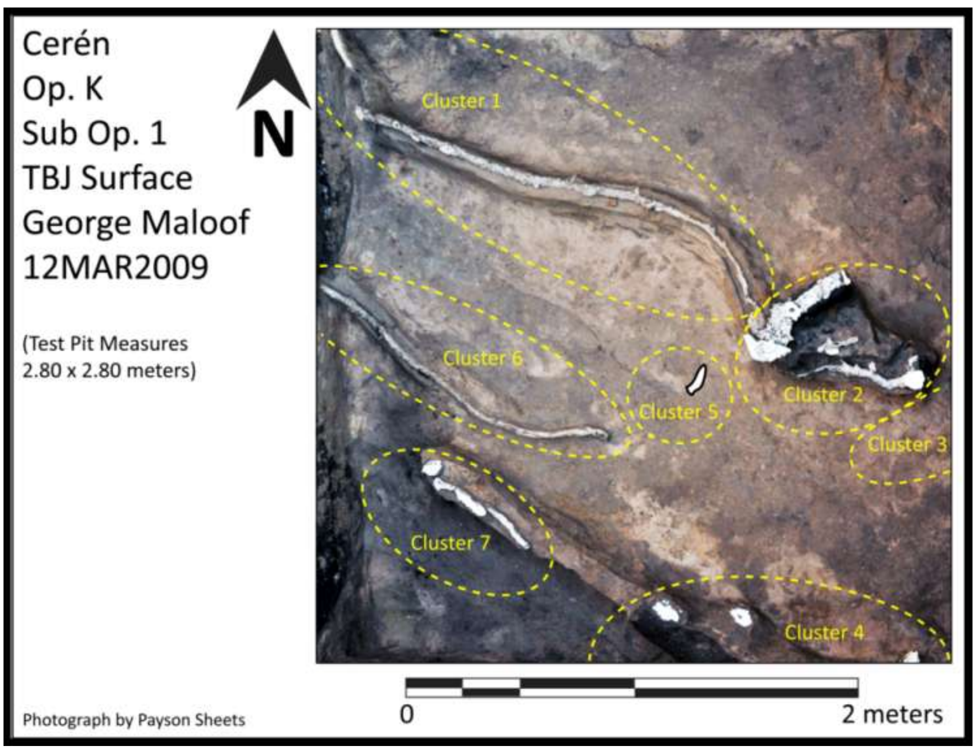

Figure 4-15. Plan View of Op. K with Plant Cluster Locations (Clusters 1-7).

Figure 4-16. Manioc Stalk and Root Fragment Cluster 2 of Op. K.

Figure 4-17. Cluster 6- Manioc Root Fragment from Op. K.

In Operation K there were a total of seven plant cast clusters recorded, Clusters 1-7, which ranged in length from 7.5cm to 228.3cm. On average these clusters had a length of 83cm, a width of 7.4cm, and a thickness of 4.2cm. Cluster 1 extended from the western to almost the eastern edge of the northern-middle surco of the operation. This plant cast was approximately 3.3cm in width and 2.2cm in thickness; however, there was great variability throughout this plant cast. The cluster documented the only hollow cavity identified in 2009 that had survived into the Unit 4 tephra of the Loma Caldera eruption. This stalk was present in the eastern end of Op. K and was cast from Unit 4 down into the TBJ surface. The stalk had a diameter of 2.5-3cm and was strong enough to survive the deposition of the coarse, hot tephra of Unit 4 (Figure 4-16).

Importantly, the stalk identified within the Unit 4 tephra connects with the long root that extended throughout the northern-middle surco of Op. K and also with an apparent branch or root that was on the surco, above the TBJ. Plant Cluster 4 was also unusually large, 192.2cm in length and approximately 4cm in width. The cast was located in the eastern portion of the western-middle surco of the Op. with roots that intertwined and extended well into the southern wall. Cluster 6 of Op. K had a length of 152cm and a width of about 3.9cm, which could possibly be a root or re-planted stalk in the manioc bed. This extended along the western part of the southern-middle surco. There are various nodules present along this plant cast that could be used to help identify this as manioc (Figure 4-17).

Op. L-1, L-2, L-3

The southwest corner of Op. L-1 was placed 3 meters north and 1 meter east of the northeastern corner of Op. F-1 (Figure 1-1). The objective of this operation was to locate the boundary between the lower, eastern manioc field of Op. F-1 and the eastern maize field of Op. G. Thus Op. L-1 was between Ops. F-1 and G and positioned along the orientation of the field boundaries in these Ops. Op L-1 documented the continuation of the field boundary between the western and eastern fields identified in Ops. F-1 and G. The eastern field of Op. L-1 was a continuation of the manioc beds located in the west of both Ops. F and G. To the east we identified ridges that were similar in shape and ridge-top width to manioc beds with broader-flat tops, however, much smaller in height (10cm) and wavelength (74cm) than typical manioc beds. Furthermore maize plant casts were excavated from these eastern surcos. Thus, it appeared in Op. L-1 we located an area where cultivation underwent a transition from manioc to maize. To better understand the planting ridges in the eastern part of Op. L-1 we extended this operation to the north and the south. The southeastern area of Op. L Sub-op 2 was positioned 2 meters east of the northwestern corner of Op. L-1. Thus Op. L-2 was also a 3 meter by 3 meter area where the northeastern corner of Op. L-1 overlapped with the southwestern corner of Op. L-2 by 1 square meter. The plant casts recovered in this square meter were identified as part of Op. L-1. The extension of Op. L-2 was intended to explore the area between the more typical looking maize fields of Op. G and those of Op. L-1. Alternatively, the Op. L-3 extension was positioned between Ops. L-1 and F-1 in order to examine the area between the eastern manioc field of Op. F-1 and the unusual maize ridges of Op. L-1. Thus extension Op. L-3 was located to the southwest of Op L-1 and along the field boundary line of Ops. F-1 and L-1 and the southwestern corner of Op. L-3 connected with the Northwestern corner of Op. F-1 (Figure 1-1).

A total of eight manioc surcos were identified in the western part of L-complex and assigned numbers 1 through 8 from south to north (Figure 4-18). In the upper or western field of the L-complex we can approximate the surco orientation as 121 degrees east of magnetic north. This approximation is based on the surco orientation of the western field in Op. F-1 where the F-2 extension allowed a much larger view of these manioc surcos. The yuca beds in the western field of the L-complex were aligned with those of the western field of Op. F-1. Interesting the boundary separating the western and eastern fields in Op. F-1 and the L-complex was oriented to 30 degrees east of magnetic north. Notably, this directionality is the same alignment as the construction of structures inside the Cerén village center. The average height of the western manioc surcos throughout the L-complex is 22cm and the average wavelength of these manioc beds is 117cm (Table 4-1). In the eastern maize fields of the operation had an average ridge height of 10cm and an average wavelength of 74cm. In the lower or eastern field of the L complex there were a total of 14 ridges, identified as ridges 1 though 14 from south to north. We did not have enough of the manioc fields in the western part of the operation to identify an accurate field orientation. In the eastern field of the L-complex, while there was a larger section of the maize fields exposed, the maize ridges were not straight or normal enough to get a

Figure 4-18. Manioc Beds and Maize Ridges of Op. L Sub-Ops.1-3.

precise measurement of directionality. Interestingly the eastern surcos of Op. F-1 had heights of 33cm for the two southern surcos and the northern most surco had a height of 16cm. This distinction of size might indicate the boundary of manioc cultivation and maize cultivation in the eastern field. Thus, it seems we had excavated a possible boundary in Op. F-1 that we did not identify until the larger pattern in the L-complex was revealed. To ensure exact location of the boundary between the manioc and maize of the eastern fields would require further excavations to the east of Op. F-1. In Op. L-3 on the western end of ridge 1, the southern-most ridge of the lower field, a manioc stalk was identified extending above the TBJ surface. Cluster 1 of Op. L-3 is approximately 10cm long, 2.8cm wide, and 2.1cm thick. This might mark the boundary between manioc and maize cultivation in this area or could possibly be a single manioc plant that has extended from the upper field down into the lower field. Without more of this ridge exposed it is not possible to determine which of these hypotheses are correct. Given the drastic change in surco height, the existence of manioc in the southernmost surco of the lower field in Op. F-1 and the presence of maize beginning in ridge number 2 of Op. L-3 it is clear that the boundary between manioc and maize cultivation is in this location.

A total of 3 plant cast clusters were identified in the western field of Op. L-1, Clusters 9, 11, and 13 (Figure 4-19). Cluster 9 had 11 small fragments that were associated with one another. The average length of these fragments is 15cm, the average width is 1.8, and the average thickness is 1.4cm. Cluster 13-D is 39cm long, 11cm wide, and 11cm thick and was recovered from surco 5 in the upper field of the L-complex. This cluster has multiple growth nodes along the root and a section of this cluster might be a tuber fragment. In Op. L-2 only 2 clusters were excavated from the western field, Clusters 11 and 12 (Figure 4-20). Cluster 12 was very large with a length of 213cm, a width along the root of 2.9, and a thickness along the root of 2.5cm. This plant cast was a large manioc root that grew uncharacteristically from one surco across a calle and into another surco (Figure 4-21). Cluster 12 has two portions that appear to be a thicker tuber or branch area with multiple shoots beginning to form up towards the top of the TBJ surface. The average width of Clusters 11 and 12 is 6cm and the average thickness is 4.3cm. In Op. L-3 a total of 3 clusters were excavated from the western field, Clusters 2, 4 and 12 (Figure 4-22). The average length of these clusters was 20cm, the average width was 2.3 cm, and the average thickness was 2 cm. Cluster 2 was a clear manioc stalk fragment with multiple growth nodes. Cluster 2-A was 8.8cm long, 2.4cm in width, and 1.9cm in thickness. Cluster 2-B was 9.5cm in length, .9cm in width, and .8cm in thickness. Cluster 4 was an unidentifiable root fragment 24.5cm in length, 2cm in width, and 2cm in thickness. Lastly, Cluster 12 was a possible manioc root fragment that was 36cm long, 3.7cm wide, and 3.3cm thick.

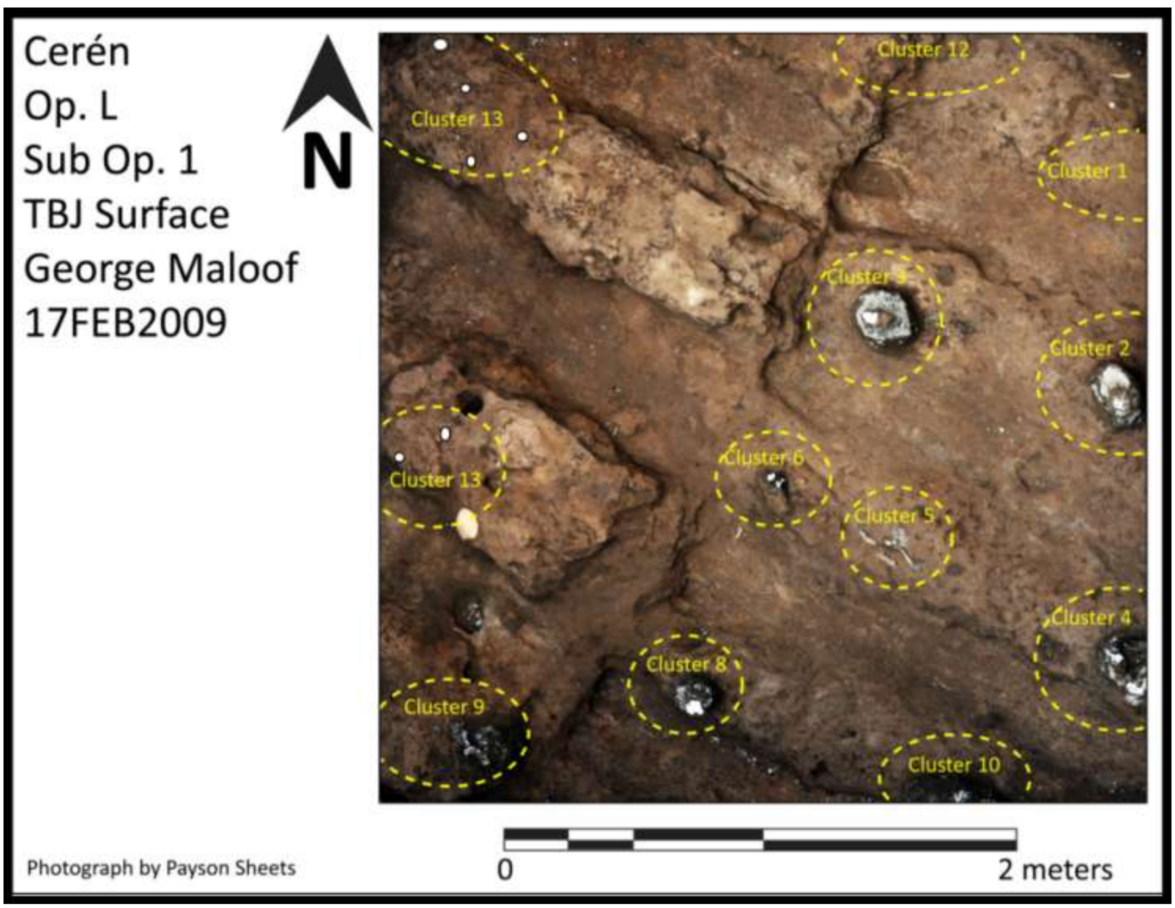

Figure 4-19. Plan View of Op. L Sub-Op. 1 with Plant Cluster Locations

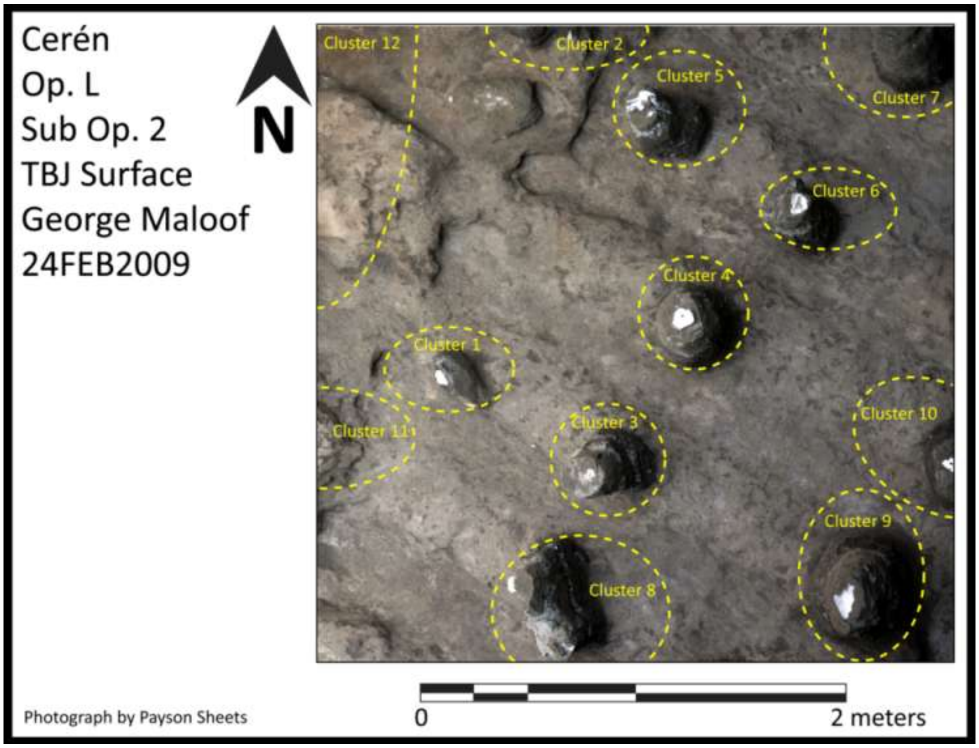

Figure 4-20. Plan View of Op. L Sub-Op. 2 with Plant Cluster Locations (Clusters 1-12).

Figure 4-21. Cluster 12: Manioc Plant Fragment from Op. L Sub-Op. 2.

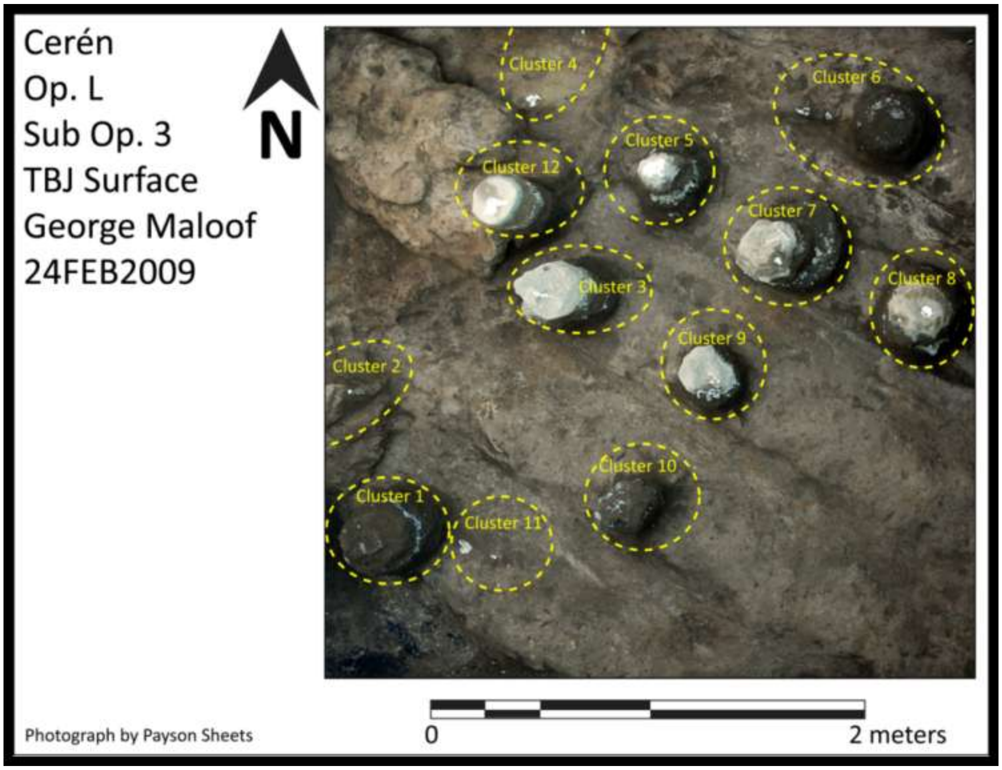

Figure 4-22. Plan View of Op. L Sub-Op. 3 with Plant Cluster Locations.

Other evidence for manioc cultivation from the 2009 field season

In various other portions of our 2009 excavations possible evidence of manioc has also been documented. The northeast corner of Op. A was located 9 meters west from the southwest corner of Op. North (Figure 1-1). In Op. A there appeared to be the faint remnants of possible surcos and calles. These were spaced 110cm, had a height of 6cm, and an orientation of 117 degrees east of magnetic north (Table 4-1). Given the surco spacing and orientation it is likely this area was a place where manioc was once cultivated but had been transformed into open space prior to the Loma Caldera eruption (See Ch. 3). Multiple plant casts found in Op. A also support the interpretation of this as a place previously used to cultivate manioc. Plant cast Clusters 1 and 4 had root like fragment connected with tuber-like, bulbous forms (Figure 4-23).

Similarly, there appeared to be possible surcos and calles present in Op. C. The southeast corner of Op. C was located 3m north and 5m west of the northwest corner of Op. B (Figure 1-1). The southwest corner of Op. C was located 15m to the northeast of Op. O. The possible surcos and calles measured approximately 100cm in wavelength and were oriented 123 degrees east of magnetic north (Table 4-1). Only one plant cast was recovered in this area (Cluster 1), which was identified as a probably manioc stalk with a growth node (David Lentz, personal communication, 2009) (Figure 3-7). Furthermore, the spacing of these abandoned ridges indicates that manioc might have been grown in this area before people decided to transform this into open space (see Ch. 3).

Figure 4-23. Manioc Plant Fragments Clusters 1 and 4 of Op. A

Figure 4-24. Clusters 2 and 5 Manioc Plants lining platform area of Op. P.

The northeast corner of Op. P was 38m from the northwest corner of Op. K (Figure 1-1). Op. P was established in alignment with the surcos in Ops. South and K of approximately 124^{o} east of magnetic north. In Op. P two manioc plant stalks were recovered extending from Unit 3 down to the TBJ surface. These manioc stalks, Cluster 2 and Cluster 5, provided evidence of manioc cultivation (Figure 4-24). Cluster 2 was 13cm in length, 1.5 cm in width, and 1.4 cm in thickness. The Cluster 5 (Plant cast: P-1-A-5) manioc stalk was approximately 16 cm in length, 4 cm in width, and 3.5 cm in thickness. While no surcos were identified in this region, both of these clusters were positioned on the northern end of the level platform area identified in the southwest corner of Op. P. While, it is possible these manioc stalks grew randomly from the midden remains documented in this region, given the location of these plants along the northern portion of the platform area, it seems more likely the manioc stalks were used to mark a boundary. Possible further evidence of manioc cultivation was also found in Op. P. The remains of three lithic artifacts from the midden of Op. P have use-wear potentially indicative of manioc processing (see Ch. 5).

The 2009 field season has provided abundant evidence for manioc cultivation at Cerén that indicates this crop was a vital part of village agriculture prior to the Loma Caldera eruption. After a brief discussion of manioc cultivation, the larger themes and implications of our research this season are explored.

Manioc Cultivation

Sweet manioc is a small perennial bush that is approximately two to three meters in height with slender stems and long leaves that contain approximately 15 to 18 percent protein (Hansen 1983). The manioc plant produces large roots and approximately five to ten tubers, which are rich in carbohydrates and a good source of vitamin B, iron, and phosphorus (Cock 1982; Hansen 1983). When compared with maize, beans, and squash, manioc is much more tolerant of environmental fluctuations and poor soil chemistry. Although the absence of water will stop manioc plants from continued growth, the tubers provide an ideal carbohydrate source during

times of drought because they remain edible underground (Hansen 1983). Additionally, manioc production requires less planting, tending, and harvesting effort that other crops in Mesoamerica (Leon 1968) and areas with good drainage and less compacted soils are best for manioc cultivation (Cock and Reyes 1985).

Our research of ancient manioc production has been greatly aided by the expertise of scientists from CENTA and local farmers from Joya de Cerén. Some of the local agriculturalists have demonstrated the process of manioc planting whereby they cut manioc stalks into approximately 20cm long stakes and plant these in the ground in pairs either side by side or one crossed over the other. These stakes then begin to produce new stalks in about 2 to 3 weeks that grow up

Figure 4-25. Traditional Grinding of Dried Manioc Tubers, Joya de Cerén.

from beneath the ground surface into new manioc plants (Cock 1985). We are told that harvest is usually 12 months after planting and a very conservative estimate of productivity is 10 pounds per plant in informal production for consumption (Quezada Perla personal communication 2009). Harvesting manioc roots is achieved through uprooting the entire plant by the stem (Cock 1985). After harvesting manioc tubers can be processed by cutting the tuber into small slices, approximately 2-3cm thick, and leaving these in the sun to dry for 8 days to one week. Once the manioc tubers have dried they can then be easily pounded and ground with a mano and metate into a fine powder, known as *almidón*, a process which was demonstrated to us by a local villager (Figure 4-25). Our informants also explained that the ground manioc substance can be used as cooking flour, a remedy for stomach ailments, an adhesive, or even a light pigment. Previous ethnographic data has also aided this research in that some areas have recorded flat-top ridges or beds used in manioc cultivation very similar to those we are finding at Cerén (Toro and Atlee 1985: 215). Harvesting is reported to require high labor output when done manually, although when planted in beds it is easier to harvest than from flat ground (Toro and Atlee 1985: 233-234). Detailed ethnographic research of traditional manioc production would greatly aid our interpretations of the Cerén archaeological record and represents one important avenue of future research.

Discussion

The 2009 Cerén archaeological field season was aimed at expanding our understanding of manioc production in the Classic Period Maya village. Guided by the discovery of manioc beds in two test pits from the 2007 season, we set out to potentially identify unharvested manioc plants, field boundaries, extent, and organization of Cerén manioc production. While unharvested manioc plants and the full extent of manioc production at Cerén were not discovered this season, great strides have been made in further comprehension of field boundaries and organization of manioc production. Furthermore, this season documented substantial variability over a short distance and a greater extent of manioc production than previously known.

One exciting aspect of our research this season has been the identification of multiple field boundaries in the area south of the Cerén village center. In Operations D, J, and H we discovered a continuous western boundary between yuca fields to the east and open space areas to the west. The termination of the manioc fields abutting open space was aligned at approximately 30 degrees east of magnetic north. Furthermore, a boundary was found in the eastern part of our excavation area this season. In Operations F-1, L-1, L-2, L-3, and G we located the eastern boundary of the yuca field identified in Test Pits 1 and 2 from 2007 and Ops. D, J, H, I, and F-2. From the western boundary in Ops. D, J, and H to this eastern boundary in Ops. F-1, L-1, L-2, L-3, and G there is a distance of approximately 15 meters. We have yet to identify the northern and southern boundaries of this particular yuca field; however, the eastern field division provides us with a limit to the western manioc fields in this region and importantly the division, like the structures of the Cerén village center, is also aligned at approximately 30 degrees east of magnetic north. The larger organization of this directionality connects these agricultural fields directly with the structures to the north. Furthermore, the alignment of field divisions and surco and ridge orientation speaks to a larger, village-level organization of agriculture.

To the east of the western yuca field identified this season we have identified two types of cultivation. First, in Op. G we located a division between manioc production in the west and maize production in the east. Such a division was also later confirmed in the L-complex excavations. The maize fields within the Op. L-complex were planted in beds that are wider than typical maize ridges identified at Cerén. This could possibly represent an area of agricultural transition from yuca to maize or a place where maize ridges were constructed larger to control for erosion. Notably, all maize fields previously excavated within the Cerén center were planted perpendicular to slope in order to provide the maize with sufficient water (Sheets 2002). In the case of the maize fields located to the east of the yuca, the maize was planted parallel to ground slope with no physical separation between the yuca and maize. Surprisingly, it appears that the yuca fields of this region are setting the broader field organization and maize is being adapted to the needs of manioc.

Previous research in the Maya area has documented the central role of maize in both diet and ideology. Our evidence indicates that in this particular case the cultivation needs of manioc are paramount to those of maize, which might demonstrate the significance of yuca to the Cerén villagers. While maize cultivation is unmistakably dominant in ideological accounts of the Classic Period Maya, maize is also much more susceptible to drought and environmental fluctuations. Thus, a partial explanation for the ideological emphasis on maize in the Maya world could be the danger or anxiety involved with its cultivation, while the dependent and relatively easily cultivated manioc would require less supernatural assistance. In light of our research this field season, as well as continued work in the Maya area to document agricultural variability, it is necessary to reconsider previous interpretations that Maya agriculture was exceedingly dependent on maize (Fedick 1996).

In Op. F-1 a second type of cultigen, yuca, was identified to the east of the western yuca field where the manioc fields of the west terminate in another manioc field. These two manioc fields have surcos and calles oriented at approximately 121 degrees east of magnetic north. There is no physical separation between the manioc fields in this Op.; however, the division between the two fields is visible in that the surcos of the western yuca field become the calles of the eastern yuca field and vice versa. The clear separation of these two fields potentially marks a division between persons or groups who owned or worked these specific areas. The partition between the eastern manioc beds of Op. F-1 and the eastern maize fields of Ops. L and G is less distinctive, but appears to be present in the southern end of the Op. L-3 and the northern end of Op. F-1.

Further evidence supporting our interpretation of different field owners or workers in the western and eastern yuca fields is present in Ops. South and K. The eastern fields documented in Ops. F-1, South, and K terminate between the area east of Op. K and west of Op. P; however, the exact nature of this termination remains unknown. The yuca beds of Ops. South and K were much larger than any other manioc beds documented at Cerén thus far. Also, the style or form of these beds was markedly distinct from the yuca bed construction in the other excavations this season and in 2007 (Figure 4-4). Where the majority of manioc surcos excavated at Cerén have had broad flat-tops, the general shape of the manioc beds in Ops. South and K were more hyperbolic along the top, with a much larger height and a much smaller width along the flat-top. The average wavelength for all of the yuca surcos identified in 2009, except for Ops. K and South, was 113cm with an average height of 22cm, while the average wavelength of surcos from Ops. K and South was 143cm and the average height was 40cm. Such evidence indicates that while all of the fields in this region remain very closely aligned with larger village organization, there is also a level of individual autonomy in agricultural choices. One model that will be further explored for land ownership at Ceren is that put forth by Netting on smallholders. Smallholders own their agricultural land and are responsible for crop production decision-making (Netting 1993; Sheets et al. 2007). The evidence of diversity in bed construction style and the separation between yuca production seems to support a model where individual farmers have a level of independence, while still being integrated into the broader village organization.

Of further interest is that all manioc beds identified thus far at Cerén have already been harvested. Hence, a large harvest occurred very recently before the Loma Caldera eruption and in some cases replanting had not yet been achieved. This broad harvest organization, with harvesting at the same time in distinct yuca fields, indicates that there was some village level synchronization to harvests. The amount of labor to harvest these fields at the same time implies that extended family networks might have been utilized. This level of harvesting also indicates that manioc was not being used simply as a household supplement where tubers were gathered only as needed. Rather, the extensive harvest of this region indicates that the yuca tubers were being processed, possibly dried and ground, for later consumption or trade.

The extent of manioc cultivation at Cerén is yet to be recorded. The yuca field that was recorded in 2007 Test Pits 1 and 2 and 2009 Ops. North, D, F-1, F-2, G, H, I, J, L-1, L-2, and L-3 has a known east to west extent of 15 meters. The northern and southern extents of this field remain unknown but are a minimum of 40 meters apart (Figure 4-2). The identification of harvested yuca beds in a road cut 200 meters northwest of our excavation area indicates the production of manioc here might be much greater than previously thought. Some field boundaries have been identified between manioc fields, open space, maize ridges, and even other manioc fields; however, there is still an unknown extension of manioc production to the north and south of our excavated area. Undoubtedly the evidence from both the 2007 and 2009 excavations at Cerén highlights the important role of yuca at Cerén. The detailed structure of the straight, well-packed calles and the carefully constructed surcos exclusively devoted to manioc production combined with the broad extent of cultivation, highlight the presence of this crop as more than a supplement in the diets of Cerén villagers. Further archaeological investigations in the agricultural fields of Cerén, as well as, increased understanding of field ownership, boundaries, and organization in ethnographic case studies will facilitate greater insight into the production, uses, and role of manioc in Classic Period Maya agriculture.

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Chapter 5. Artifacts and Soils

Payson Sheets

The title of this chapter, “Artifacts and Soils,” might at first glance seem like a strange combination of categories. However, I believe the soils in the agricultural fields can be considered, to a large degree, an artifact of human activity. Certainly the shape of the fields, with large ridges and swales for manioc, and smaller ones for maize, were human creations during the Middle Classic period. Furthermore, the forming of the ridges and the anthroturbation caused by planting and harvesting mixed the juvenile “tierra blanca joven” soil with the underlying well-weathered and clay-rich pre-Ilopango soil. The roots of most plants contacted both soil horizons. Thus, the topics of artifacts and soil fertility are not as divergent as they might first appear and this chapter will discuss the ceramic and lithic artifacts encountered in the 2009 field season at Cerén, as well as the soil fertility of these sixth and early seventh centuries AD agricultural fields. The artifacts are presented in Table 5-1, and the soils analyses and interpretations are presented in Appendix 5-A.

The 3 x 3 meter excavations, and their extensions, varied considerably in artifact content. Some operations had no artifacts, while others, such as Ops. F and P, had abundant artifacts, especially sherds. In contrast to the edges of sherds from mound fill at other Salvadoran sites and those found in the context of active agricultural operations at Ceren, the Op P midden sherds exhibited crisp and “fresh” breaks.

Other than the basalt scraper, the laja smoothing stones, and the usewear on the larger obsidian prismatic blade from Operation P, the artifact assemblage collected in this season is very similar to the artifacts encountered by excavations within the Cerén site center some 150 meters to the north.

A tiny, unidentified bone fragment was found in the Operation P midden.

Comments on individual chipped stone artifacts

Two basalt artifacts were found in the midden in Operation P (Fig 5-1). One is a large scraper, described below. The other is a small percussion flake, 3.8 x 2.4 x .6 cm. The flake has stream cobble cortex over its entire dorsal surface. The platform is crushed on the dorsal side, and the most distal portion of the flake is missing, but probably was only a few millimeters long. The flake began to hinge toward the distal end, leaving a predominance on the core, and thus creating a minor difficulty for sustained flaking. Its presence in this midden is evidence of reasonably competent percussion manufacture of basalt among these Cerén commoners. The details of that manufacture, and resharpening, must await future discoveries of finished tools, resharpened tools, and manufacturing wastage. Fortunately, along with the flake, we found a basalt scraper that had been extensively used and resharpened.

Figure 5-1. Chipped stone artifacts from Operation P, the midden. The basalt scraper on the left has extensive usewear at bottom, with three attempts to resharpen it that were unsuccessful, and it was discarded. The prismatic blade on the left has pronounced striational usewear on its margins, and may have been used to cut the cortex off of manioc tubers. Two prismatic blade fragments and a basalt flake are also included.

That basalt scraper found in the midden in Operation P deserves special attention. It was made from a fine-grained, dense basalt that is not native to the Cerén area. The closest outcrop or alluvial/colluvial basalt source is not known, but probably is ten or more kilometers distant. Only one small area retains cortex from the original rock, and it appears to be stream worn, indicating an alluvial source. That cortex formed the platform, some of which crushed on the ventral side from the extreme percussive force used to create the large flake. The original flake probably was longer than 15 cm, and may have been longer than 20 cm, judging from the morphology and the lack of radial fissures on the ventral surface toward the scraping edge. The scraper measures 7.1 cm in length (along the direction of force axis), 10.8 cm in width, and 4.7 cm in thickness. It appears to have been resharpened many times, as remnants of 11 resharpening flakes are visible on its dorsal surface. Three attempts were made to resharpen the scraper, resulting in detaching small flakes from its distal working edge. One ended in a hinge fracture, another in a step fracture and the other in a feather edge, but none carried far.

The working edge of the scraper exhibits considerable usewear, other than the places where small resharpening flakes were removed. The directionality of the abrasion is perpendicular to the edge, as indicated by small striations visible in slant light with a 10x hand lens and a 40 power binocular microscope. The abrasion is consistent with working something with a lot of dirt or grit on it. I here suggest that it is a scraper used to remove the cortex (outside dark hard coating) of the manioc tuber. Even with sweet manioc, the cortex contains considerable amounts of hydrogen cyanide, and a scraper would be a way to remove it. The only kind of stone tool manufacturing technique discovered to date within the Cerén site is resharpening of scrapers, and within the site they were resharpening scrapers of obsidian in Household 1. They evidently could resharpen scrapers of basalt in the fields, in addition to resharpening obsidian scrapers in the village. A village-to-village exchange system may have operated among manioc processors, with part-time specialists making the large percussion blades near the basalt source. Or it is also possible that some attached specialists in elite centers did the initial manufacture of the large percussion blades and shaping into scrapers. Regardless of where and how the initial manufacturing was conducted, it is clear that the use and the resharpening of basalt scrapers was accomplished locally.

Four proximal segments of obsidian prismatic blades retained platforms that were moderately striated prior to their removal from the core, as was common among Maya blademakers in the Classic period. The platform sizes (ave. 9 x 4 mm) are also consistent with Classic period manufacture. The longest blade (6.0 cm) was extensively used and may have been discarded because of the use-nicking (microfracturing 2 mm or smaller) and considerable abrasive wear that significantly dulled the tool. The abrasive wear, parallel to the edge, indicates this tool was used in a sawing, rather than a cutting, motion. Abrasive wear is clearly visible along both margins, and on one up to 5 mm away from the cutting edge. Cutting the cortex of manioc longitudinally could cause this type of abrasive wear. In the usual processing of manioc people longitudinally cut the cortex of manioc, open it up, and peel away the exterior skin from the interior carbohydrate-laden tuber. That four or five times more abrasive wear is on one edge, compared to the other, may indicate a handedness in the user, but whether that is right or left handed is not clear. The other three blades had moderate to slight use-nicking, and two may have been discarded because they were too short, rather than too dulled by use.

The distal and the 7 medial segments exhibit use wear ranging from significant to almost nonexistent. One has quite pronounced wear from nicking, and some pressure flaking to retouch steeply the edge. The others had mild, slight, to non-detectable use nicking.

The shorter proximal segment (4.7 cm) retains no abrasive wear evidence, and only slight use nicking. It might have been discarded because of breakage into a segment too short to hold and use conveniently.

The third obsidian prismatic blade is a medial segment (1.8 x .9 x .3 cm) retains very extensive usewear in the form of microflaking and abrasion along both edges and the distal tip. It suffered post-abandonment damage in the form of trampling, probably by people walking on it and perhaps other forms of turbation. The random scratches and abrasion on ventral and dorsal surfaces indicates it was greatly trampled after discard.

Figure 5-2. Laja artifacts from Operation P.

Five dacite lajas were found in the basurero of Operation P. One shows no evidence of being worked or having been used. It has stream cobble cortex all over it, so it was collected from a stream and carried into the field, but for what purpose is unknown. A small laja (ave. diameter 8.8 cm, thickness 1.7 cm) evidently was used as a hammerstone. It retains the evidence of percussive use against something hard, probably another stone, on the protuberances of its margins. Some of the impacts were hard enough to induce some minor fracturing. Three lajas vary in size but not in their characteristics (dimensions: ave diameter 11 cm, 2.8 cm thick, 11.5 cm and 3.4 cm, and 12.7 cm and 3 cm). Each was used extensively as a hammerstone, as evidenced by the pounded margins and some inadvertent fracturing. Each also retains evidence of abrasion along shallow ridgetops and around their margins. They evidently were used as handstones for smoothing something abrasive. They could have been used as smoothing stones to flatten out tbj tephra surfaces such as the flattened area in the southwest corner of Operation P.

A total of 35 polychrome sherds were recovered from all operations, and a total of 185 undecorated sherds from utilitarian vessels. Polychromes represent 19% of the collection, a percentage only slightly lower than that in the Cerén site itself.

Figure 5-3. Copador Polychrome sherds from Operation P.

Notes on the artifacts from Operation F:

A small fragment of a trough metate was recovered, and it appears to have been used for many years before it broke and was discarded, as it is only 3.8 cm thick. It is a quite vesicular andesite. It is the form of the metate that was heavily used on the floor of Structure 11, the kitchen of Household 1, and not the form of the bulky metates that were supported by horquetas in that same household.

A small cubical fired clay artifact was also found, measuring 2.6 by 2.2 by 1.2 cm. It was low temperature fired, unslipped, and only roughly shaped, with finger indentations on both faces. It might have been used as a gaming piece.

Figure 5-5. Artifacts from Operation F. Lip fragment of trough metate, small cubical fired clay object, two polychrome sherds, and a sherd from a scraped slip utilitity vessel.

Notes on the ceramic artifacts from Operation P, the midden:

A spindle whorl was found in the Op. P basurero, 3.3 cm in diameter, 1.1 cm thick, with the hole (spindle) diameter 6 mm. It is complete, and of the size for making cotton thread.

Figure 5-6. Ceramic artifacts. Adorno, mouthpiece of whistle, spindle whorl, and redware adorno.

A mouthpiece element of a whistle was recovered, unslipped, 2.5 cm in length. The whistle chamber is almost entirely missing. Also unslipped is an adorno that might have been attached to an incensario, with two ear-like protuberances that are 2.2 cm long. A small fragment of plastic decoration of a redware vessel measures 2.4 by 2.1 by 1.4 cm, with one protuberance resembling a human nose, and the other smaller one unclear. Six vessel handles were found, five of which were incomplete and one of which was complete and still attached to a large Guazapa scraped-slip sherd. Also found was an annular base to an unslipped orangeware vessel, with a base diameter of 7.7 cm.

Operation	Suboperation	#	No. Sherds	Sherd Information	Chipped Stone	Ground Stone
D	1		1	Undiagnostic body sherd, angular breaks		
E	1		4	3 undiag. Body sherds, 1 thin orange rim sherd from bowl		
F	1		57	2 Copador Polychrome sherds, 3 red-on-buff, 5 Guazapa scraped-slip, 2 thin orange bowl rimsherds, 3 rimsherds, 41 body sherds, 1 squared item 2.6 x 2.2 x 1.2 cm.		Trough Metate: well shaped, lip, 3.8 cm thick
F	2		1	1 Olla handle fragment		
G	1		3	3 body sherds		
I	1		2	Rimsherd from large thick bowl, thin body sherd		
K	1		6	1 Copador Polychrome sherd, 1 red-on-buff bowl rimsherd, 3 body sherds		
L	1		10	2 large sherds from Copador Polychrome bowls (1 with geometric motif of "U and dots"), 2 rimsherds (1 Guazapa scraped slip) and 3 body sherds. [L-3 had 3 undiagnostic body sherds.]		
N	1		1	Undiagnostic thick body sherd		
P	1		111	122 Undiagnostic body sherds with fresh breaks, 5 Olla handle fragments, 7 Guazapa scraped slip sherds (one with handle), 3 squared-	4 proximal segments of obsidian prismatic blades, striated platforms, 7 medial prismatic	

				top rim sherds from large bowls, 2 rimsherds from thin red-painted bowls, 2 rimsherds from large darkware jars, 1 spindle whorl, 1 undecorated annular base, 1 bodysherd from fine blackware, 2 modeled adornos, 29 Copador Polychrome sherds (incl. 16 rimsherds).	blade segments, 1 distal prismatic blade segment, 1 basalt percussion flake, 1 basalt scraper on large percussion flake with extensive usewear. 5 Lajas.	
S	1		3	2 undiagnostic body sherds, 1 flared-rim redware bowl.		
W	1		1	Copador Polychrome body sherd		

Table 5:1. Analysis of Ceramic and Lithic Artifacts by Operation and Category.

Soils

The agricultural engineers at CENTA (Centro Nacional de Technologia Agropecuaria y Forestal) Laboratorio de Suelos, particularly Ing. Qurino Argueta, have been helpful in identifying manioc, and especially helpful in analyzing Classic period soils buried by the Loma Caldera tephra. As can be seen in the soil analysis data (Appendix A), the soils in which the maize and manioc were growing were reasonably fertile, but they were not exceptionally fertile. Soil sampling focused on two quite different soils, a juvenile one on top, and a well-weathered one below. Both soils were neutral in pH, and high in potassium, copper, and low in zinc and organic material (as with tropical soils generally). The juvenile soil on the top level was forming on the tierra blanca joven volcanic ash from the Ilopango volcanic eruption, and was only some two centuries in formation after the eruption. That soil has a very open, loose texture that facilitated growth of manioc tubers and roots. It had higher phosphorous, manganese, iron, and copper than the lower clay-laden soil. The lower soil, weathered for a long time before Ilopango erupted, had much higher clay content than the tbj soil, and thus usually discouraged manioc tuber and root growth. The lower soil was much lower than the tbj soil in phosphorous, and lower in iron and manganese and copper than the tbj soil. I suspect a reason for the high productivity of maize in this area, in the village of Cerén as well as these fields to the south, was because the roots (prop roots and tap root) had access to both soils. Therefore, each maize plant could make up for a deficiency in an element in one soil by tapping into the other soil. Manioc does not need the fertile soils that maize requires, but does need well drained and relatively loose soils to grow effectively. The manioc surcos were placed on the side of the hill with the steeper slope, averaging about ten degrees, which would have given better drainage than if planted on the less inclined land to the west or to the east. Perhaps that is why there was a zone of manioc cultivation at about the same elevation and maximum slope, with cleared areas above, and maize cultivation below.

Appendix 5-A Soils data from CENTA.

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San Andrés, 29 de enero de 2009

CARTA No. 20014

NOMBRE DEL AGRICULTOR: PAYTON SHEETS
CANTON: JOYA DE CEREN
MUNICIPIO: SAN JUAN OPICO
DEPARTAMENTO: LA LIBERTAD

No. Laboratorio	Muestra 20027	Muestra 20028	Muestra 20029
Identificación muestra	SS1 ESTE SURCO	SS2 ESTE SURCO FONDO	SS3 ESTE CALLE

RESULTADO DEL ANALISIS

Textura por Bouyoucos		FRANCO ARENOSO		FRANCO ARCILLO ARENOSO		FRANCO ARENOSO	
	% Arena	75.68		55.68		69.68	
	% Arcilla	14.32		24.32		8.32	
	% Limo	10.00		20.00		22.00	
pH en agua		7.0	NEUTRO	6.8	NEUTRO	7.0	NEUTRO
Fósforo	(ppm)	152	MUY ALTO	2	MUY BAJO	119	MUY ALTO
Potasio	(ppm)	104	ALTO	272	MUY ALTO	121	ALTO
Zinc	(ppm)	1.12	BAJO	0.95	BAJO	1.15	BAJO
Manganeso	(ppm)	5.25	ALTO	5.01	BAJO	6.84	ALTO
Hierro	(ppm)	34.94	MUY ALTO	8.56	BAJO	26.01	MUY ALTO
Cobre	(ppm)	3.86	MUY ALTO	2.22	ALTO	5.28	MUY ALTO
Materia Orgánica	(%)	0.14	BAJO	1.08	BAJO	0.41	BAJO
Calcio	(Meq/100g)	3.17	BAJO	11.57	ALTO	3.63	BAJO
Magnesio	(Meq/100g)	1.42	BAJO	6.40	ALTO	1.58	BAJO
Potasio	(Meq/100g)	0.27		0.70		0.31	
Sodio	(Meq/100g)	0.19	NO SODICO	0.30	NO SODICO	0.22	NO SODICO
Suma de Bases	(Meq/100g)	5.05	MEDIO	18.97	MEDIO	5.74	MEDIO
Acidez Intercambiale	(Meq/100g)	0.0	BAJO	0.0	BAJO	0.0	BAJO
CICE	(Meq/100g)	5.05	MEDIO	18.97	MEDIO	5.74	MEDIO
Saturación de Bases (%)		100		100.0		100.0	
Relacion Calcio/Magnesio		2.23	MEDIO	1.81	BAJO	2.30	MEDIO
Relacion Magnesio/Potasio		5.26	MEDIO	9.14	MEDIO	5.10	MEDIO
Relacion Calcio+Magnesio/Potasio		17.0	MEDIO	25.67	MEDIO	16.81	MEDIO
Relacion Calcio/Potasio		11.74	MEDIO	16.53	MEDIO	11.71	MEDIO

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San Andrés, 22 de enero de 2009

DESCRIPCIÓN DE LAS MUESTRAS DE SUELOS RECOLECTADAS EN LA CALICATA (SS1-SS2-SS3 ESTE) DE JOYA DE CEREN SAN JUAN OPICO, DEPARTAMENTO DE LA LIBERTAD, EL SALVADOR C.A.

- Las muestras de suelo SS1-ESTE en la parte superior del surco, textura franco-arenoso, pH en agua 7.0 N, Fósforo 152 ppm interpretado como muy alto, Potasio 104 ppm interpretado como alto y los demás análisis: Materia orgánica 0.14% Bajo, Zinc 1.12 ppm Bajo, Calcio 3.17 meq/100g Bajo, Magnesio 1.42 meq/100g Bajo, Densidad 1.43g/cc.

- La muestra de suelo SS2-ESTE en el fondo del surco, textura franco-arcillo-arenoso, pH en agua 6.8 N, Fósforo 2 ppm interpretado como Muy Bajo, Potasio 272 ppm interpretado como Muy Alto, Zinc 0.95 ppm Bajo, Manganeso 5.01 ppm Bajo, Hierro 8.56 ppm Bajo, Materia orgánica 1.08% Bajo, y resulto Bajo la Relación Calcio/Magnesio 1.81 Bajo, Densidad 1.13 g/cc.

- Muestra de suelo SS3-ESTE tomada en la calle con textura Franco-Arenoso, pH en agua 7.0 N, Fósforo 119 ppm interpretado como Muy Alto, Potasio 121 ppm interpretado como Alto, Zinc 1.15 ppm Bajo, Materia orgánica 0.41% Bajo, Calcio 3.63 meq/100g Bajo, Magnesio 1.58 meq/100g Bajo, Densidad 1.27g/cc.

1,2,3

3

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CONCLUSIÓN

La textura en la parte superior tuvo una variación en el contenido de Arcilla, Arena y Limo, al comparar con la muestra tomada al fondo del surco. El pH se mantuvo, el Fósforo varió de 152 ppm a 2.0 ppm. Se concluye que este elemento es poco móvil en el suelo conservando su contenido en la zona de siembra del maíz, el Potasio varió de 104 ppm en la parte superior a 272 ppm en el fondo del surco, debido a que este elemento tiende a lixiviar de la capa superior hacia el fondo del perfil.
Los demás elementos como Zinc, Manganeso y Hierro se encontraron con bajos niveles de disponibilidad, de la misma manera la materia orgánica que resultó con porcentaje bajo, debido a que la temperatura fue alta y esto hizo que la Materia orgánica desapareciera, caso similar se da en suelos tropicales con temperaturas altas.

Al comparar la muestra tomada en la calle (SS3-ESTE), con la muestra de suelos(SS1-ESTE) la textura (Franco-Arenoso), pH, Fósforo y Potasio resultaron similares en sus niveles suficientes, y los resultados de Zinc, Calcio, Magnesio y Materia orgánica fueron interpretados como Bajos, estas características similares se atribuyen a que las muestras están en la zona de la siembra del maíz.

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San Andrés, 29 de enero de 2009

CARTA No. 20014

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DEPARTAMENTO: LA LIBERTAD

No. Laboratorio	Muestra 20030	Muestra 20031	Muestra 20032
Identificación muestra	SS4 SUR SUPERFICIE	SS5 SUR FONDO	SS6 SUR CALLE

RESULTADO DEL ANALISIS

Textura por Bouyoucos		FRANCO ARENOSO	FRANCO ARCILLO ARENOSO	FRANCO ARCILLO ARENOSO
	% Arena	75.68	61.68	65.68
	% Arcilla	8.32	20.32	24.32
	% Limo	16	18	10.0
pH en agua		7.0 NEUTRO	6.8 NEUTRO	6.8 NEUTRO
Fósforo	(ppm)	143 MUY ALTO	6 MUY BAJO	1 MUY BAJO
Potasio	(ppm)	117 ALTO	207 MUY ALTO	288 MUY ALTO
Zinc	(ppm)	1.01 BAJO	1.23 BAJO	1.45 BAJO
Manganeso	(ppm)	3.27 BAJO	4.20 BAJO	3.27 BAJO
Hierro	(ppm)	22.96 MUY ALTO	24.40 MUY ALTO	22.26 MUY ALTO
Cobre	(ppm)	3.51 MUY ALTO	4.34 MUY ALTO	7.80 MUY ALTO
Materia Orgánica (%)		0.28 BAJO	0.55 BAJO	0.80 BAJO
Calcio	(Meq/100g)	3.61 BAJO	9.84 ALTO	11.14 ALTO
Magnesio	(Meq/100g)	1.97 BAJO	5.75 ALTO	6.47 ALTO
Potasio	(Meq/100g)	0.30	0.53	0.74
Sodio	(Meq/100g)	0.25 NO SODICO	0.32 NO SODICO	0.38 NO SODICO
Suma de Bases	(Meq/100g)	6.13 MEDIO	16.44 MEDIO	18.73 MEDIO
Acidez Intercambiale	(Meq/100g)	0.0 BAJO	0.0 BAJO	0.0 BAJO
CICE	(Meq/100g)	6.13 MEDIO	16.44 MEDIO	18.73 MEDIO
Saturación de Bases (%)		100.0	100.0	100.0
Relacion Calcio/Magnesio		1.83 BAJO	1.71 BAJO	1.72 BAJO
Relacion Magnesio/Potasio		6.57 MEDIO	10.84 MEDIO	8.74 MEDIO
Relacion Calcio+Magnesio/Potasio		18.60 MEDIO	29.42 MEDIO	23.80 MEDIO
Relacion Calcio/Potasio		12.03 MEDIO	18.57 MEDIO	15.05 MEDIO

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San Andrés, 22 de enero de 2009

DESCRIPCIÓN DE LAS MUESTRAS DE SUELOS RECOLECTADAS EN LA CALICATA (SS4-SS5-SS6 SUR) DE JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO DE LA LIBERTAD, EL SALVADOR C.A.

- La nuestra de suelo SS4-SUR parte superior del surco, tiene una textura franco-arenosa, pH 7.0 Neutro, Fósforo 143 ppm interpretado como Muy Alto, Potasio 117 ppm interpretado como Alto, el Zinc 1.01 ppm Bajo, Manganeso 3.27 ppm Bajo, Materia orgánica 0.28% Bajo, Calcio 3.61 meq/100g Bajo y Magnesio 1.97 meq/100g Bajo, relación Calcio/Magnesio 1.83 Bajo y Densidad aparente 1.35 g/cc.

- La muestra de suelo SS5-SUR, fondo del surco tiene una textura Franco-Arcillo-Arenoso, pH 6.8 Neutro, Fósforo 6.0 ppm interpretado como Muy Bajo, Potasio 207 ppm interpretado como Muy Alto, el Zinc 1.23 ppm Bajo, Manganeso 4.20 ppm Bajo, y Materia orgánica 0.55% Bajo, relación Calcio/Magnesio 1.71 Bajo y Densidad aparente 1.10 g/cc.

- La muestra de suelo SS6-SUR, tomada de la calle muestran los resultado siguientes: textura Franco-Arcillo-Arenoso, pH en agua 6.8 Neutro, Fósforo 1.0 ppm interpretado como Muy Bajo, Potasio 288 ppm interpretado como Muy Alto, Zinc 1.45 ppm Bajo, Manganeso 3.77 ppm Bajo, Materia orgánica 0.80% Bajo, relación Calcio/Magnesio 1.72 Bajo y Densidad aparente 1.02 g/cc, y los demás elementos en niveles suficientes.

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CONCLUSIÓN

Al hacer comparaciones de las muestras de suelo SS4-SUR, SS5-SUR, los resultados de análisis solamente el Fósforo es diferente que va de 143 ppm a 6.0 ppm. Caso contrario del Calcio que va de 3.61 meq/100g a 9.84 meq/100g, el Zinc, Manganeso, Materia orgánica y relaciones Calcio/Magnesio mostraron bajo contenido, causa que se le puede atribuir a que las cenizas volcánicas son bajas en estos elementos, nuevamente la Materia orgánica desaparece por altas temperaturas de la misma manera los resultados nutricionales de la calle SS6-SUR fueron similares a los análisis de la SS5-SUR. En conclusión los suelos donde se cultivaba en épocas precolombinas eran ricos en minerales para el desarrollo y producción de las plantas para el caso de maíz y yuca.

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San Andrés, 29 de enero de 2009

CARTA No. 20014

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DEPARTAMENTO: LA LIBERTAD

No. Laboratorio	Muestra 20033	Muestra 20034	Muestra 20035
Identificación muestra	SS7 NORTE SURCO	SS8 NORTE FONDO	SS9 NORTE CALLE

RESULTADO DEL ANALISIS

Textura por Bouyoucos		FRANCO ARENOSO		FRANCO ARCILLO ARENOSO		FRANCO ARCILLO ARENOSO	
	% Arena	72.96		54.96		58.96	
	% Arcilla	10.32		29.04		27.04	
	% Limo	16.72		16		14	
pH en agua		6.8	NEUTRO	6.7	NEUTRO	6.7	NEUTRO
Fósforo	(ppm)	90	MUY ALTO	1	MUY BAJO	1	MUY BAJO
Potasio	(ppm)	157	ALTO	224	MUY ALTO	239	MUY ALTO
Zinc	(ppm)	1.11	BAJO	1.01	BAJO	1.09	BAJO
Manganeso	(ppm)	3.27	BAJO	6.72	ALTO	3.99	BAJO
Hierro	(ppm)	32.67	MUY ALTO	16.97	ALTO	24.10	MUY ALTO
Cobre	(ppm)	4.93	MUY ALTO	3.87	MUY ALTO	4.72	MUY ALTO
Materia Orgánica	(%)	0.41	BAJO	1.08	BAJO	0.69	BAJO
Calcio	(Meq/100g)	4.29	ALTO	11.30	ALTO	10.90	ALTO
Magnesio	(Meq/100g)	3.10	ALTO	7.21	ALTO	7.10	ALTO
Potasio	(Meq/100g)	0.40		0.57		0.61	
Sodio	(Meq/100g)	0.20	NO SODICO	0.29	NO SODICO	0.29	NO SODICO
Suma de Bases	(Meq/100g)	7.99	MEDIO	19.37	MEDIO	18.90	MEDIO
Acidez Intercambiale	(Meq/100g)	0.0	BAJO	0.02	BAJO	0.0	BAJO
CICE	(Meq/100g)	7.99	MEDIO	19.39	MEDIO	18.90	MEDIO
Saturación de Bases (%)		100.0		99.89		100.0	
Relacion Calcio/Magnesio		1.38	BAJO	1.57	BAJO	1.54	BAJO
Relacion Magnesio/Potasio		7.75	MEDIO	12.65	MEDIO	11.64	MEDIO
Relacion Calcio+Magnesio/Potasio		18.48	MEDIO	32.47	MEDIO	29.51	MEDIO
Relacion Calcio/Potasio		10.73	MEDIO	19.82	MEDIO	17.87	MEDIO

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San Andrés, 22 de enero de 2009

DESCRIPCIÓN DE LAS MUESTRAS DE SUELO RECOLECTADAS EN LA CALICATA (SS7-SS8-SS9 NORTE) DE JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO DE LA LIBERTAD, EL SALVADOR C.A.

- La muestra de suelo SS7-NORTE, parte superior del surco, los resultados de análisis físico-químico fueron: textura Franco-Arenoso, pH 6.8 Neutro, Fósforo 90.0 ppm interpretado como Muy Alto, Potasio 157 ppm interpretado como Alto, Zinc 1.11 ppm Bajo, Manganeso 3.27 ppm Bajo, Materia orgánica 0.41% Bajo y la relación Calcio/Magnesio 1.38 Bajo y Densidad aparente 1.36 g/cc.

- La muestra de suelo SS8-NORTE tomada del fondo del surco, los resultados son los siguientes: textura Franco-Arcillo-Arenoso, pH en agua 6.7 Neutro, Fósforo 1.0 ppm Muy Bajo, Potasio 224 ppm Muy Alto, Zinc 1.01 ppm Bajo, Materia orgánica 1.08% Bajo, relación Calcio/Magnesio 1.57 Bajo.

- La muestra de suelo SS9-NORTE colectada en la calle, los análisis físico-químicos son los siguientes: textura por Bouyoucos, Franco-Arcillo-Arenoso, pH en agua 6.7 Neutro, Fósforo 1.0 ppm Muy Bajo, Potasio 239 ppm Muy Alto, Zinc 1.09 ppm Bajo, Manganeso 3.99 ppm Bajo, Materia orgánica 0.69% Bajo, relación Calcio/Magnesio 1.54 Bajo y Densidad aparente 1.19 g/cc.

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CONCLUSIÓN

Al comparar las muestras SS7-NORTE con SS8-NORTE se encontró que los análisis físico-químicos tienen una tendencia a mostrar diferencia en textura, Densidad aparente, Fósforo, Potasio, Manganeso, siendo similares en pH, Zinc y relación Calcio/Magnesio. Pero al comparar el suelo SS8-NORTE y SS9-NORTE son similares en sus características físicas y químicas.

Al concluir en forma general, los suelos extraídos de los tres sitios, los resultados de los análisis demuestran que eran suelos agrícolas con un horizonte "A" ricos en minerales tales como Fósforo y Potasio, esto indica que eran suelos fértiles formados por dos horizontes A y C clasificados taxonomicamente como inceptisol. Perfil que iniciaba su proceso de formación a partir de cenizas volcánicas, pero que las áreas agrícolas fueron cubiertas por cenizas y fragmentos de lava. A estas evidencias las conocemos como suelos enterrados.

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San Andrés, 9 de febrero de 2009

CARTA No. 20029

NOMBRE DEL AGRICULTOR: PAYTON SHEETS
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MUNICIPIO: SAN JUAN OPICO
DEPARTAMENTO: LA LIBERTAD

No. Laboratorio	Muestra 20078	Muestra 20079
Identificación muestra	YUCA PARTE SUPERIOR	YUCA PARTE INFERIOR

RESULTADO DEL ANALISIS

Textura por Bouyoucos		FRANCO ARENOSO		FRANCO ARCILLO ARENOSO	
	% Arena	74.96		56.96	
	% Arcilla	11.04		29.04	
	% Limo	14		14	
pH en agua		7.3	NEUTRO	7.2	NEUTRO
Fósforo	(ppm)	112	MUY ALTO	4	MUY BAJO
Potasio	(ppm)	123	ALTO	283	MUY ALTO
Zinc	(ppm)	1.61	BAJO	1.66	BAJO
Manganeso	(ppm)	5.81	ALTO	7.35	ALTO
Hierro	(ppm)	30.82	MUY ALTO	17.33	ALTO
Cobre	(ppm)	4.18	MUY ALTO	4.80	MUY ALTO
Materia Orgánica	(%)	1.08	BAJO	1.74	BAJO
Calcio	(Meq/100g)	4.20	ALTO	11.25	ALTO
Magnesio	(Meq/100g)	2.10	ALTO	7.40	ALTO
Potasio	(Meq/100g)	0.32		0.73	
Sodio	(Meq/100g)	0.22	NO SODICO	0.34	NO SODICO
Suma de Bases	(Meq/100g)	6.84	MEDIO	19.72	MEDIO
Acidez Intercambiale	(Meq/100g)	0.0	BAJO	0.0	BAJO
CICE	(Meq/100g)	6.84	MEDIO	19.72	MEDIO
Saturación de Bases	(%)	100		100	
Relacion Calcio/Magnesio		2.0	BAJO	1.52	BAJO
Relacion Magnesio/Potasio		6.56	MEDIO	10.14	MEDIO
Relacion Calcio+Magnesio/Potasio		19.7	MEDIO	25.55	MEDIO
Relacion Calcio/Potasio		13.13	MEDIO	15.41	MEDIO

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San Andrés, 12 de febrero de 2009

DESCRIPCIÓN DE LA CALICATA OPERACIÓN "G" SITIO ARQUEOLOGICO JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO LA LIBERTAD, FEBRERO, 5 DE 2009

YUCA, PARTE SUPERIOR

Los análisis químicos son: pH en agua 7.3 Neutro, Fósforo 112 ppm interpretado como Muy Alto, Potasio 123 ppm Alto, Manganeso 5.81 ppm Alto, Hierro 30.82 ppm Muy Alto, Cobre 4.18 ppm Muy Alto, Calcio y Magnesio Alto, las relaciones Magnesio/Potasio, Calcio + Magnesio/ Potasio y Calcio/Potasio, resultaron en contenidos Medios. Los resultados Bajos fueron el Zinc 1.61 ppm Bajo, la Materia orgánica 1.08% Bajo y la relación Calcio/Magnesio Bajo. Los análisis físicos: Textura Franco Arenoso, Densidad aparente 0.981 gramos por centímetro cúbico (0.981 g/cm^3) color café oscuro amarillento. Estas características tanto químicas y físicas indican que el suelo era excelente para obtener buenos resultados de rendimiento de raíces de yuca.

Al comparar los análisis químicos de la parte inferior donde se sembraba la yuca existe diferencia en el contenido de Fósforo de 4 ppm interpretado como Muy Bajo, Potasio 283 ppm interpretado como Muy Alto, pH en agua 7.2 Neutro, el Zinc se mantuvo similar, lo mismo que la Materia orgánica y la relación Calcio/Magnesio. Las propiedades físicas incrementaron el porcentaje de Arcilla, es lógico que el horizonte estaba en proceso de formación y comenzaba la diferenciación de horizontes. Textura Franco Arcillo Arenosa, Densidad aparente (1.06 g/cm^3) color café muy oscuro.

DESCRIPCIÓN DE LA CALICATA OPERACIÓN "G" SITIO ARQUEOLOGICO JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO LA LIBERTAD, FEBRERO, 5 DE 2009

RESUMEN

Al hacer comparaciones de las muestras Yuca, parte superior y Yuca parte inferior se encontraron diferencias, en textura de Franco Arenoso a Franco Arcillo Arenoso de parte superior a inferior, la razón es que se iniciaba la diferenciación del perfil por una acumulación de Arcilla lo cual se demuestra en la hoja de análisis.

El Fósforo en la parte superior es interpretado como Muy Alto y en la parte inferior Muy Bajo (112 ppm a 4 ppm de Fósforo). Este elemento tiene poca movilidad en el suelo y su contenido Muy Alto se le atribuye a los residuos vegetales sobre la superficie antes de que fuera enterrado por materiales fragmentarios de grava y ceniza. En el caso del Potasio es menor el contenido en la parte superior que en la parte inferior que va de 123 ppm a 283 ppm de Potasio, este caso se le atribuye a que el elemento Potasio se lixivia fácilmente de parte superior del perfil hacia la inferior.

Al analizar los pH con sus rangos neutros de 7.3 a 7.2 se interpreta como suelos con acumulación de sales de la zona superior de donde se tomaron las muestras que esta compuesto por fragmentos de lava y cenizas.

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TECNICO EN FERTILIDAD DE SUELOS

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San Andrés, 9 de febrero de 2009

CARTA No. 20030

NOMBRE DEL AGRICULTOR: PAYTON SHEETS
CANTON: JOYA DE CEREN
MUNICIPIO: SAN JUAN OPICO
DEPARTAMENTO: LA LIBERTAD

No. Laboratorio	Muestra 20080	Muestra 20081
Identificación muestra	MAIZ PARTE SUPERIOR	MAIZ PARTE INFERIOR

RESULTADO DEL ANALISIS

Textura por Bouyoucos		FRANCO ARCILLO ARENOSO		FRANCO ARCILLO ARENOSO	
	% Arena	56.96		56.96	
	% Arcilla	23.04		27.04	
	% Limo	20.00		16.00	
pH en agua		7.4 MEDIANAMENTE ALCALINO		7.2 NEUTRO	
Fósforo	(ppm)	153	MUY ALTO	3	MUY BAJO
Potasio	(ppm)	91	ALTO	230	MUY ALTO
Zinc	(ppm)	1.47	BAJO	1.50	BAJO
Manganeso	(ppm)	4.40	BAJO	7.70	ALTO
Hierro	(ppm)	26.93	MUY ALTO	22.10	MUY ALTO
Cobre	(ppm)	2.96	ALTO	3.93	MUY ALTO
Materia Orgánica	(%)	0.52	BAJO	0.83	BAJO
Calcio	(Meq/100g)	2.76	BAJO	11.00	ALTO
Magnesio	(Meq/100g)	1.35	BAJO	7.33	ALTO
Potasio	(Meq/100g)	0.23		0.59	
Sodio	(Meq/100g)	0.21	NO SODICO	0.30	NO SODICO
Suma de Bases	(Meq/100g)	4.55	BAJO	19.22	MEDIO
Acidez Intercambiale	(Meq/100g)	0.0	BAJO	0.0	BAJO
CICE	(Meq/100g)	4.55	BAJO	19.22	MEDIO
Saturación de Bases	(%)	100		100	
Relacion Calcio/Magnesio		2.04	BAJO	1.50	BAJO
Relacion Magnesio/Potasio		5.87	MEDIO	12.42	MEDIO
Relacion Calcio+Magnesio/Potasio		17.90	MEDIO	31.07	MEDIO
Relacion Calcio/Potasio		12	MEDIO	18.64	MEDIO

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San Andrés, 12 de febrero de 2009

DESCRIPCION DE LA CALICATA OPERACIÓN "G" SITIO ARQUEOLOGICO JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO DE LA LIBERTAD, FEBRERO 5 DE 2009

MAÍZ PARTE SUPERIOR

Los análisis químicos como: pH en agua 7.4 moderadamente alcalino, Fósforo 153 ppm Muy Alto, Potasio 91 ppm Alto, Hierro 26.93 ppm Muy Alto, Cobre 2.96 Alto y resultaron bajos: Zinc, Manganeso, Calcio, Magnesio, Materia orgánica y la relación Calcio/Magnesio. Al analizar lcs resultados de análisis físicos las variaciones no son muy marcadas con respecto a la operación "G" Yuca de la parte superior, debido a que la cercanía donde se sacaron las muestras no son tan distantes como para establecer diferencias, en cuanto a las propiedades físicas Textura, Franco Arcillo Arenoso en las dos muestras, color café oscuro en la parte superior del maíz y en la parte inferior café muy oscuro. En la operación "G" Maíz no se tomo muestras para densidad aparente.

DESCRIPCION DE LA CALICATA OPERACIÓN "G" SITIO ARQUEOLOGICO JOYA DE CEREN, SAN JUAN OPICO, DEPARTAMENTO DE LA LIBERTAD, FEBRERO 5 DE 2009

RESUMEN

Al comparar las dos muestras de la operación "G" Maiz, tienen características similares a la operación "G" Yuca. Se considera nuevamente que el suelo era excelente para la producción agrícola de la época precolombina. Estos suelos tenían un desarrollo adecuado para la agricultura, característica que se observan en la diferenciación del perfil ya sea por color y textura de los horizontes muestreados.

En la operación "H" solamente se hizo muestreo para densidad aparente, densidad aparente parte superior 1.172 g/cm^3 y color café grisáceo muy oscuro y en el horizonte inferior o parte inferior la densidad aparente es 0.965 g/cm^3 y color café claro.

Al observar el sitio de las calicatas el origen de los suelos muestreados son de cenizas volcánicas en el cual se inicia la diferenciación del perfil y que con la erupción del cerro caldera quedo como suelo enterrado, donde los precolombinos diseñaban sus cultivos de subsistencia.

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Paleoethnoboanical Studies at the Cerén Site, 2009 Season

David L. Lentz and Angela N. Hood

Introduction

The Cerén site offers an extraordinary opportunity to gain a firm understanding of plant use practices of the ancient Maya through the study of archaeological plant remains. The rapid deposition of tephra on the activity surfaces of the site over 1400 years ago resulted in well preserved plant parts and impressions of plants where they once grew at the time of the Loma Caldera eruption. Through an examination of these plant remnants we can not only learn what plants were being used at Cerén, but we can also ascertain how plants were grown in the immediate vicinity of the Cerén village at the time of the eruption. These efforts are critical to the advancement of our comprehension of Maya agriculture and agroforestry because at Cerén we can see the full range of plants being used, particularly those plants whose tissues do not preserve well, such as root crops, that may be invisible at other sites.

Because of the excellent preservation at Cerén, the site provides a model for the testing of assumptions and approaches at other sites in the Maya realm. It has been our intention to recover plant remains using all current paleoethnobotanical techniques. We have employed macrofossil collection, examination of plaster casts taken from plant impressions captured in soil, water flotation of soil sediments, and analysis of special soil samples for their content of pollen, phytoliths and starch grains. Through the application of these approaches, it is our hope to extract the maximum amount of paleoethnobotanical data possible from this exceptional site. This chapter begins with a discussion of the methodology for collecting data on modern plants from the contemporary community of Joya de Cerén, as well as for collecting paleoethnobotanical remains from the ancient Cerén site. Following the section on methodology, we present the preliminary results of our modern plant survey and the analysis of paleoethnobotanical remains (carbonized macroremains and planter casts) from the 2007-2009 excavations at Cerén.

Methodology

Modern Plant Data and Ethnographic Information

We gathered data on the modern flora of Joya de Cerén by identifying trees, shrubs, vines and herbaceous plants growing around the project area, which is adjacent to the Rio Sucio (approximately 175 meters to the east), and in the gardens of graciously welcoming inhabitants of Joya de Cerén. Ethnographic information detailing how these plants are currently used was gathered by conducting formal interviews with Salvadoran informants about the plants growing in their gardens, and shorter, more informal interviews with our knowledgeable field crew and neighbors. We recorded the plants growing in Joya de Cerén with photographs, sketches, and the collection of leaves, stems, fruits, seeds, and inflorescences for a comparative ethnobotanical collection.

Flotation collection

In the course of the 2009 Cerén excavations, samples of the Tierra Blanca Joven (TBJ) soil from the activity surfaces of Operations F, L and M were carefully excavated with clean trowels (to prevent contamination from other cultural contexts), measured in two liter samples, and bagged for flotation processing. The two liter samples collected from each of these sub-operations were processed by water flotation. A total of 10 liters of soil was processed from Operations F, L, and M: two liters from Operation F, six liters from Operation L, and two liters from Operation M. A sealed midden, or basurero, uncovered below the TBJ in Operation P received special treatment regarding the collection of flotation samples – the entire feature (bisected into northwestern and southwestern portions) was collected for flotation processing. Two liter sub-samples were subsequently collected from each of these 65 larger flotation samples and were processed by water flotation, for a total flotation sample of 130 liters from the sub-TBJ midden in Operation P.

A manual water flotation technique was employed to process the samples collected from Operations F, L, M, and P. Each two liter soil sample was added to a basin containing approximately 6 gallons of water, and the soil was gently agitated by hand to liberate carbonized plant materials from their soil matrix, or the heavy fraction. A light fraction of charcoal and other carbonized plant remains floated to the water's surface and was collected by pouring water from the basin into a fine mesh screen (150 µm sieve opening). The light fraction of each sample was carefully removed from the screen and dried between several layers of paper. When dry, the carbonized plant remains of the light fraction were placed in properly labeled paper bags and sealed for transport to the University of Cincinnati for further analysis using stereomicroscopy, scanning electron microscopy, and Lentz's plant reference collection.

Macroremains

The majority of paleoethnobotanical macroremains – carbonized plant materials such as seeds, rinds, and wood charcoal – were recovered during the excavation of activity surfaces at Cerén during the 2009 field season. Due to the fragile nature of macroremains, each specimen was carefully collected with trowels or bamboo tools and placed in small boxes to ensure safe transport back to the field laboratory in Joya de Cerén. Once in the laboratory, each macroremain was separated and packaged for safe shipment back to the University of Cincinnati for further analysis. Carbonized macroremains also were recovered from the light fraction of soil samples processed by water flotation. Lentz identified several of these macroremains to the species level with the aid of a stereomicroscope at the field laboratory in Joya de Cerén, and the details of these identifications are discussed below under the "Preliminary Identifications" section.

Pollen

Pollen grains, unlike macroremains, are microscopic plant remains that cannot be seen during excavation, and our methods for collecting pollen specimens from activity surfaces at Cerén reflect this distinction. Soil discolorations (an ash lens identified in the sub-TBJ midden of Operation P, for example) were collected with clean trowels and stored in paper bags when encountered during the excavation of activity surfaces. Soil samples for pollen analysis were also collected from the TBJ surface of the surcos and calles uncovered in Operation L, with the intent of identifying pollen that had settled on these activity surfaces before the Loma Caldera eruption. Identifying these surface pollen specimens may reveal other plant species cultivated in adjacent fields by Cerén's ancient inhabitants or species growing in forests surrounding the site. Soil excavated beneath *in situ* artifacts – such as the matrix excavated beneath a polychrome ceramic vessel in Operation L, sub-Operation 1, Surco 4 – was collected to identify any pollen that may have been present on the artifacts' downturned surfaces. Finally, the interior surfaces of ceramics and groundstone artifacts (laja 4 recovered from the sub-TBJ midden in Operation P, for example) were scraped with sterile bamboo probes to liberate any pollen grains attached to their porous surfaces, and the samples were stored in sterile envelopes for transport to the University of Cincinnati. Given the microscopic size of pollen grains, magnification with a compound microscope and a scanning electron microscope is required for their identification, and the samples gathered during the 2009 field season at Cerén will be analyzed upon the authors' return to the United States.

Phytoliths

Like pollen, phytoliths are microscopic plant remains too small to be seen by the unaided eye. Phytoliths are created when the tissues of some living plants sequester silica and, under certain circumstances, these tissues preserve quite well as distinctive forms that can be identified to species. The soil samples taken from activity surfaces and beneath *in situ* artifacts for pollen analysis will also be examined for phytoliths using light and electron microscopy. Furthermore, phytoliths might be present on the porous surfaces of ceramic and groundstone artifacts recovered from activity areas excavated at Cerén, and the residues scraped from these artifacts will be examined with these remains in mind. The phytoliths identified from these samples may reveal economically significant plant species at Cerén that otherwise are not preserved as macroremains or plaster casts.

Starch grains

Starch grains, like pollen and phytoliths, are microscopic plant remains that sometimes are present on the surfaces of groundstone artifacts, such metates and lajas, and the interior surfaces of ceramic vessels, a signature left by foodstuffs once processed or stored in these artifacts. Once documented *in situ,* groundstone, one chipped stone artifact, and several ceramic artifacts uncovered in Operations L and P were carefully excavated and transported to the field laboratory in Joya de Cerén where they were scraped with sterile bamboo probes. The residues from these treatments were collected in sterile envelopes, then sealed for transport to the University of Cincinnati. The single chipped stone artifact – a basalt scraper exhibiting extensive usewear – was also treated for starch grain analysis because the utilized edge may have been used to process plant foods. Starch grain samples were also taken from five metates recovered from past field seasons at Cerén (curated at the Museo Nacional David J. Guzman) using the same sterile bamboo probe and envelope collection method employed at the field laboratory in Joya de Cerén. Soil samples collected for pollen and phytolith analysis will also be examined for starch grains.

Preliminary results

Modern Plant Data

During our survey of plants growing around Joya de Cerén, we noted economically important species as well as common weeds, trees, and ornamentals. Table 1 lists the species we observed, including their family and common names, growth habit, and uses. While not all the plants growing around Joya de Cerén today were cultivated by the ancient inhabitants, several species observed during our survey, such as *Theobroma cacao* (cacao) and *Cucurbita pepo* (squash), made significant contributions to the ancient subsistence base and continue to be economically important plant resources. To draw parallels between our ethnobotanical survey of Joya de Cerén and the plants used by the ancient Cerén inhabitants, the following discussion focuses on those plant species identified in the Cerén paleoethnobotanical assemblage that can still be found growing in the modern Joya de Cerén community.

We observed *Curcurbita pepo*, also known as ayote or squash, growing in a garden among maize, beans, banana trees, and bougainvillea in a fenced area approximately 200 meters southeast of the project area. Seeds and a dried peduncle of *C. pepo* have been identified from contexts in the Cerén village (Lentz and Ramírez-Sosa 2002), and Lentz has made a preliminary identification of a *Curcurbita* sp. rind from Operation P-1, collected during the 2009 field season.

Examples of manioc (also known as yuca), or *Manihot esculenta*, grew right in our courtyard in Joya de Cerén, planted by Dr. Sheets, Christine Dixon, George Maloof, and Andy Tetlow as an experiment comparing the plants' distinctive woody stem and thick starchy roots with the plaster plant casts recovered from the 2007-2009 Cerén excavations. Manioc was also offered in vegetable stands at open-air market in San Juan Opico and in a supermarket in Lourdes, El Salvador. Plaster casts of manioc stems and roots have been uncovered in house gardens at Cerén, and plaster casts of manioc stems and roots have been identified from Operations C-1, P-1, and L-1,2, and 3.

Nance (*Byrsonima crassifolia*), is an edible fruit-bearing tree we observed growing in the garden of Maria Candelaria Guerra Orellana, a citizen of Joya de Cerén who kindly invited us into her garden. Nance pits measure approximately 2 cm in diameter, and the fruit surrounding the relatively large pit is eaten fresh. Paleoethnobotanical remains of nance stems and fruits have been identified from the activity surfaces of households at Cerén, where nance trees, along with other economically important species, were planted in household courtyards (Lentz and Ramírez-Sosa 2002).

The cedro tree, *Cedrela odorata*, is a tropical deciduous tree growing in Joya de Cerén, and its wood is used today to build cabinetry. Wood charcoal specimens of *Cedrela* sp. have been identified from roof fall contexts in Cerén households, thus the cedro tree remains identified at Cerén have been interpreted as likely used by the site inhabitants as a building material (Lentz and Ramírez-Sosa 2002).

Cacao trees, *Theobroma cacao*, also were observed growing in Joya de Cerén, where their seeds are used to make a chocolate beverage. Evidence of cacao trees abound from the ancient Cerén village as well, where a cacao tree with an attached inflorescence was uncovered, along with plaster casts of cacao fruit pods and preserved seeds (Lentz and Ramírez-Sosa 2002). Cacao residue found in a finely painted ceramic vessel at Cerén, along with ethnographic literature describing the use of cacao in rituals, indicate that cacao was an important component of ritual activity at the site (Lentz and Ramirez-Sosa 2002). Further analysis will reveal whether cacao is present in the paleoethnobotanical assemblage recovered during the 2009 field season.

Maize (*Zea mays*) was a staple crop at Cerén and at other sites throughout the Maya area, and many fields are currently planted in the crop at Joya de Cerén. The field in which the 2009 excavations took place had been planted in maize earlier in the season, and the dried stalks, leaves, and prop roots of the harvested crop stood in stark contrast to the 1,400 year-old maize plants preserved in plaster along surcos 3 meters below the modern fields. Rarely is the past so tangible. Our preliminary analysis has identified maize casts in Operation L-1, 2, and 3, and Operation P-1 (see Chapter 2).

During our preliminary analysis of macroremains, Lentz identified the pit of a jocote or hogplum (*Spondias purpurea*) from the sub-TBJ midden in Operation P. This specimen is the first evidence of the species at ancient Cerén. We also found the tree bearing jocote fruits in a dooryard garden at Joya de Cerén during our modern plant survey of the area. The modern villagers of Joya de Cerén consume the fruits of jocote fresh and it seems likely that the inhabitants of the ancient Cerén village followed the same practice.

Family	**Species**	**Common Name**	**Growth habit**	**Use**
		Dicotoledóneas		
Amaranthaceae	*Amaranthus spinosus*	bledo, amaranth	Herb	leaves eaten as pot herb
Anacardiaceae	*Anacardium occidentale*	marañon, cashew	Tree	fleshy hypocarp eaten fresh
	Mangifera indica	mango	Tree	edible fruit
	Spondias purpurea	jocote, hogplum	Tree	edible fruit
Annonaceae	*Annona diversifolia*	anona	Tree	edible fruit
Apocynaceae	*Stemmedenia donnell-smithii*	cojón de caballo	Tree	latex used as an adhesive
Aristolochiaceae	*Aristolochia maxima*	guaco	Vine	young pods cooked & eaten
Asteraceae	*Bidens* sp.	mozote, beggar's tick	Herb	common weed
Bignoniaceae	*Tabebuia chrysantha*	cortez	Tree	wood used for construction
	Tecoma stans	San Andres	Shrub	Ornamental
Bixaceae	*Bixa orrelana*	achiote	Shrub	seeds used as a flavoring
Bombacaceae	*Ceiba pentandra*	ceiba	Tree	trunks used for canoes
Boraginaceae	*Cordia alliodora*	laurel	Tree	wood used for furniture
Burseraceae	*Bursera simaruba*	jiote	Tree	resin used for incense
Cactaceae	*Pereskia autumnalis*	matial	Shrub	planted as a living fence
Caricaceae	*Carica papaya*	papaya	Tree	edible fruit
Cercropiaceae	*Cercropia peltata*	guarumo	Tree	pioneer species
Cucurbitaceae	*Cucurbita pepo*	ayote, squash	Vine	edible fruit, oil from seeds
	Luffa cylindrica	luffa, pax te	Vine	cooking oil from seeds, vegetable sponge from fruit
	Sechium edule	huisquil, chayote	Vine	edible fruit
Euphorbiaceae	*Jatropha curcas*	piñon	Tree	fruits used medicinally
	Manihot esculenta	yuca, manioc	Shrub	edible tubers, leaves eaten as a pot herb
	Ricinus communis	higuero castor bean	Tree	medicinal oil from seeds

Leguminosae	*Delonix regia*	flamboyan, flame tree	Tree	Ornamental
	Enterolobium cyclocarpum	guanacaste, conacaste	Tree	pods eaten by cattle, wood used in cabinetry
	Erythrina guatemalensis	pito	Tree	flowers eaten
	Gliricidia sepium	madre de cacao	Tree	shade tree
	Inga sp.	paterna	Tree	edible fruits
	Phaseolus vulgaris	frijol, black beans	Vine	seeds edible, crop
Malpighiaceae	*Byrsonima crassifolia*	nance	Tree	edible fruit
Meliaceae	*Cedrela odorata*	cedro	Tree	wood used in cabinetry
Moraceae	*Ficus benjamanii*	fig	Tree	Ornamental
	F. glabrata	chilamate	Tree	riverine tree
Piperaceae	*Piper* sp.	cordoncillo	Shrub	Ornamental
Rutaceae	*Citrus aurantium*	naranja agria	Tree	edible fruit
Sapotaceae	*Calocarpum mamossum*	zapote	Tree	edible fruit
	Chrysophyllum caimito	caimito, star apple	Tree	edible fruit
Simaroubaceae	*Simarouba glauca*	negrito	Tree	edible fruit
Solanaceae	*Solanum* sp.	hierba	Shrub	medicinal plant
Sterculiaceae	*Guazuma ulmifolia*	guazuma	Tree	edible fruit
	Theobroma cacao	cacao	Tree	beverage from seeds
Verbenaceae	*Lantana camera*	cinco negritos	Herb	Ornamental
		Monocotiledóneas		
Araceae	*Alocacia* sp.	aroid	Herb	riverine species
Arecaceae	*Cocos nucifera*	cocos	Tree	edible fruit
Bromeliaceae	*Ananas comosus*	piña, pinapple	Herb	edible fruit
	Bromelia pinguin	pinuela	Herb	edible fruit
Cyperaceae	*Cyperus canus*	tule	Herb	stems used to make petites
Musaceae	*Musa paradisiaca*	plátano	Shrub	edible fruit
Poaceae	*Bambusa vulgaris*	bambú	Shrub	Ornamental
	Saccharum officinarum	caña	Shrub	stem is a sugar source
	Zea mays	maiz	Herb	kernels eaten

Table 6-1. Modern plants in the Joya de Cerén area, 2009.

Paleoethnobotanical results: Operation M-1

Operation M was excavated in the northwestern portion of the 2009 project area. The TBJ activity surface appears to have been shaped as a cultivated area with surcos and calles. However, severe weathering and trampling by Cerén's ancient inhabitants have created a possible footpath along the western wall of Operation M (see Chapter 3). Although Operation M was not cultivated at the time of the Loma Caldera eruption, three plant clusters set in plaster were identified within the testpit: Clusters 1 and 2 likely represent tree trunks, and Cluster 3, a thin stalk, did not possess distinctive characteristics necessary for identification. One six-liter flotation sample was excavated from the TBJ activity surface of the west wall of Operation M, and a two-liter sub-sample was processed with water flotation, the light fraction of which will be analyzed at the University of Cincinnati.

Operation L-1, 2, 3

Operation L, sub-Operations 1, 2, and 3 were planted in manioc and maize at the time of the Loma Caldera eruption, with a boundary between wider surcos and calles for manioc beds and more narrow maize beds extending south-west (see Chapters 2 and 4). Plaster casts of manioc stalks and roots, as well as maize stalks, prop roots, cobs, and kernels were identified from all three sub-Operations of Operation L. One six-liter flotation sample was collected from each sub-Operation in Operation L, and a two-liter sub-sample from each of these was processed with water flotation. Soil samples were also collected from the activity surface of each sub-Operation for pollen, phytolith, and starch grain analysis. Additionally, the interior surface of a polychrome ceramic vessel from sub-Operation 1 was scraped and the residue collected for pollen, phytolith, and starch grain analysis.

Operation P-1

In Operation P-1, excavations to the TBJ activity surface uncovered a relatively flat, uncultivated area with a large block of pre-Classic period clay located in the south-central portion of the unit on top of the TBJ surface. Several cavities were discovered and promptly filled with dental plaster, revealing manioc stems in Clusters 2 and 5 and a maize stalk in Cluster 4. Upon excavation beneath the TBJ activity surface, a midden, measuring approximately 3 meters north-south by 2 meters east-west, was uncovered 6 centimeters below the TBJ surface and yielded ceramic sherds, lajas, obsidian blade fragments, and an abundant sample of paleoethnobotanical macroremains. The manioc and maize stalks growing in Operation P were probably volunteers growing from the rich organic midden soil sealed beneath the TBJ. Preliminary analysis of these macroremains has identified frijoles, or common beans (*Phaseolus vulgaris*); frijol luna, or lima beans (*Phaseolus lunatus*); ayote or squash rind (*Curcurbita* sp.); an aguacate or avocado cotyledon (*Persea americana)*; a jocote or hogplum pit (*Spondias purpurea*); and maiz or corn kernels (*Zea mays*). All ceramic sherds and lajas recovered from the midden were scraped with sterile bamboo probes to collect residue from their porous surfaces for pollen, phytolith, and starch grain analysis.

Preliminary Identifications

Table 2 lists the tentative identifications of paleoethnobotanical macroremains and plant casts. The majority of archaeological plant remains and all of the microbotanical evidence within the soil samples collected in the 2009 Cerén field season are still unidentified. Further analysis at the Plant Resources Laboratory at the University of Cincinnati will advance our understandings of ancient Cerén agricultural practices.

Species	Part	Family	Common Name	Context
Cucurbita sp.	Rind	Cucurbitaceae	ayote, squash	Op. P-1
Manihot esculenta	Stem and tuber casts	Euphorbiaceae	yuca, manioc	Op. C-1, Op. P-1,Op. L-1,2,3
Persea americana	Cotyledon	Lauraceae	aguacate, avocado	Op.P-1
Phaseolus lunatus	Seed	Leguminosaeae	frijol luna, lima bean	Op. P-1
P. vulgaris	Seed	Leguminosaeae	frjol, common bean	Op. L-1, Op. P-1
cf. *Pachyrrhizus erosus*	Root cast	Leguminosaeae	jícama, yam bean	Test pit 3
Spondias Purpurea	Pit	Anacardiaceae	jocote, hogplum	Op. P-1
Zea mays	Kernels, cob & stem casts	Poaceae	maiz, corn	Op. L-1,2,3, Op. P-1

Table 6-2. Cerén paleothnobotanical remains, 2007-2009 seasons.

References Cited:

Lentz, D.L.and C.R. Ramírez-Sosa. 2002. Cerén plant resources: Abundance and diversity. In: Before the Volcano Erupted: The Cerén Village in Central America, Sheets, P.D., ed., pp. 33-42. University of Texas Press, Austin.

Chapter 7: Photographic Mapping & Photographic Profiling

George O. Maloof

Introduction

The mapping of structures, deposits, excavation units and stratigraphic profiles is an integral part of careful archaeological research. Traditional archaeological mapping, however, can be tedious and in the case of most projects of limited duration, a heavy drain of that most important available resource: time. Additionally, the accuracy of these maps is directly proportional to the amount of time and effort put into their creation; the more time invested in their elaboration, the more accurate the final product. Finally, although in a drawn map or profile many particularities can be represented by distinctive symbols or drawn textures, the actual textures, colors, and appearances cannot accurately represented (Alexander Zanesco, Personal Communication, May 2005).

The 2009 field season conducted south of the Joya de Cerén site was used as a test for a novel approach to excavation unit mapping and stratigraphic profiling. Using high-resolution digital photography and a process of photographic distortion removal, photographic maps and profiles are quickly and easily obtained. These maps generally exceed the precision and detail of tradition mapping and profiling methods without the use of very expensive photogrammetric equipment.

Methodology

Photographic Mapping

Prior to taking the photograph, the floor of the unit is prepared by placing large nails, whose heads have been marked with a small square of neon green flagging tape, into each of the four corners of the excavation pits at a fixed distance of the size of the excavated test pits. The positions of the nails were verified in a similar manner to the initial layout of the pits on the surface, by measuring the hypotenuse to guarantee that each of the corners were at 90 degrees. In the case of the 3 x 3 meter Cerén operations, the hypotenuse was 4.242 meters. Once the distances and angles were confirmed, the photograph was taken as near perpendicular to the test pit floor as possible, while insuring that all four nails were visible (Figure 7-1).

Upon returning to the laboratory, the photograph was downloaded onto the computer and opened for processing in Adobe Photoshop CS3. The photograph was then adjusted for color balance, brightness and contrast and the presence and visibility of the nails is confirmed. Once the distortion was removed for the photograph, a second layer was opened and the *Custom Shape Tool* was selected. The *Fixed Size* button was then selected and dimensions of 15 x 15 cm were entered to define the size of the square, although this actual dimension is not important as long as both dimensions are the same. The box corresponding with the *From Center* option was then also selected. The cursor was placed at the center of the excavation photograph, insuring that the new layer was the one that selected, and then the mouse was clicked, causing a semi-transparent box to appear over the photograph (Figure 7-2).

Figure 7-1: Photograph as-taken prior to processing. Note the nails near each corner, demarcated by the red circles (Operation I, photograph by Payson Sheets).

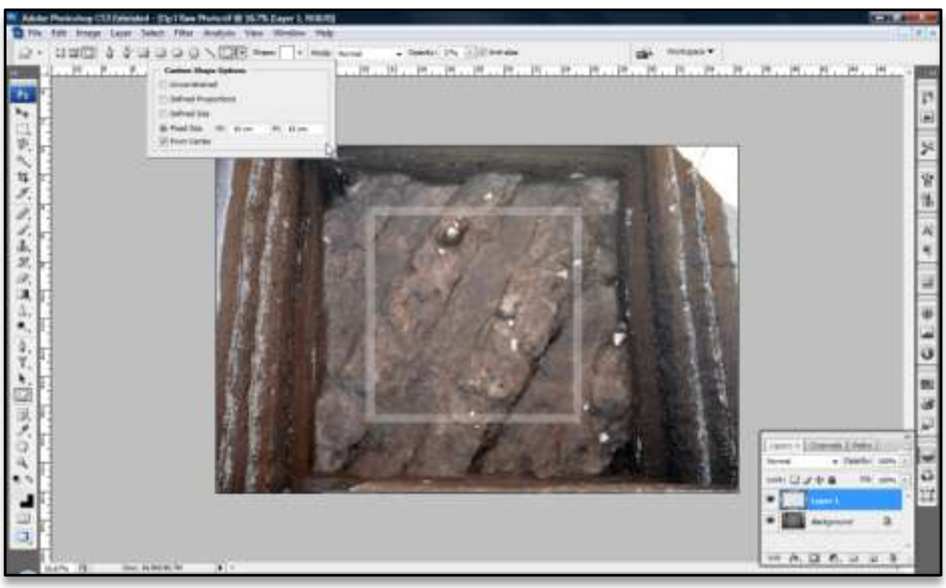

Figure 7-2: Adobe Photoshop CS3 Screen shot showing the custom shape tool dialogue box and the transparent box in place.

Once the box was in place, the second layer was deselected and the original background layer, the photograph, was selected. The *Rectangular Marquee Tool* was then selected and the area of the photograph containing the four nails was demarcated. Once this was done, the *Transform* option was opened from the *Edit* drop down menu and the *Distort* option was selected. This caused the appearance of eight small boxes along the perimeter of the selected area. By left-clicking on one of these boxes and dragging the mouse while maintaining the button depressed, the photograph could then be distorted in virtually any direction. In order to remove the distortion from the photograph for the purposes of generating the photographic map, the photograph was distorted as such that each of the four nails were pulled to the exact corner of the superimposed semi-transparent square (Figure 7-3). Once each nail was in its correct position, *Enter* was pressed in order to register the changes to the photograph. The *Crop Tool* was then selected and the photograph was cropped to the exact edges of the overlain box, insuring that the alignment of all four nails was maintained.

The photograph was then oriented on the north-south axis, with north being at the top of the screen, and then the photographic map was ready to be used where needed. In the case of the 2009 Joya de Cerén field season, the photographic map was transferred into Adobe Illustrator and set into the established map format template (Figure 7-4).

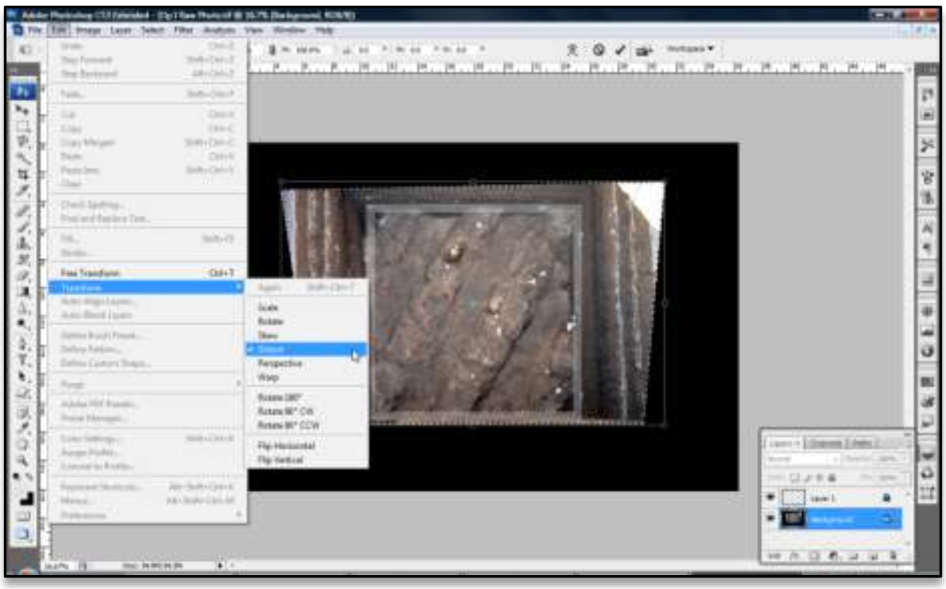

Figure 7-3: Adobe Photoshop CS3 Screen shot showing the distort tool dialogue box and the photograph adjusted.

Photographic Profiling

The process of photographic profiling is very similar to that of photographic mapping. In this case, the horizontal distance between the nails is determined by the desired length of the profile of interest. In the case of the 2009 Joya de Cerén field season that distance was three meters. The vertical distance is determined by the overall depth of the profile; however the actual distance is not as important as the ratio between it and the horizontal distance. In Joya de Cerén, the vertical was one meter, a 3:1 ratio, horizontal to vertical.

To layout the nails, a string with a line level is placed in order to establish a horizontal plane. The vertical position of this plane should be selected in order to be able to have the center of the rectangle formed by the four nails to be roughly in the center of the profile. The first two nails are placed along the established vertical plane at the established distance from each other. From these nails, the desired vertical distance is measured below the first pair of nails and the second pair of nails is placed in the same manner as the first two. In order to verify the positioning of the upper plane to the lower plane, a plumb bob is utilized, insuring 90 degree

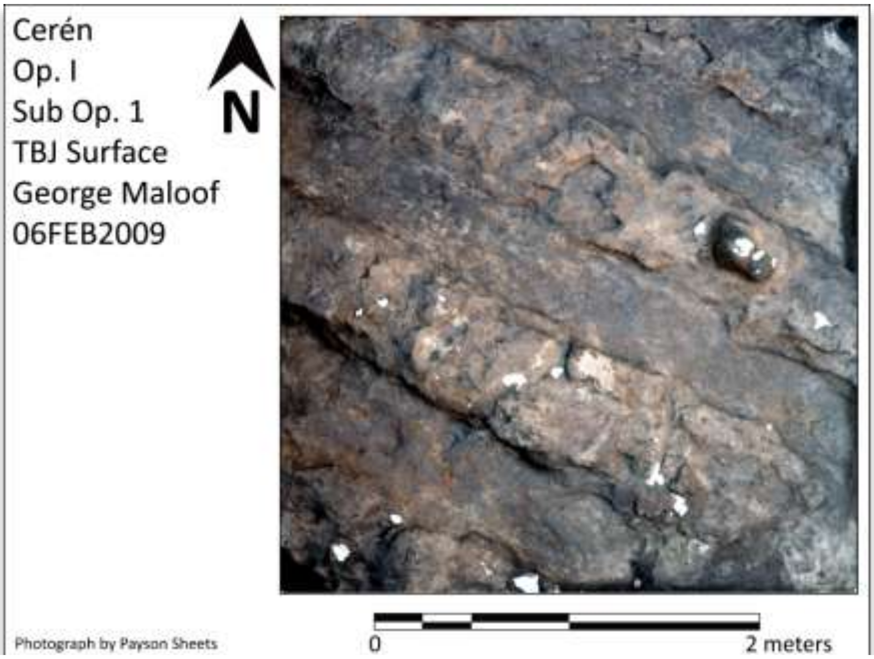

Figure 7-4: Example of a completed and oriented photographic map inserted into the project template.

angles at the four corners. Once the nails are in place, the photograph can be taken as perpendicularly as possible to the profile, insuring that all four nails are visible. In the case of some of the Cerén profiles, the height of the wall being profiled was taller than was possible to fit in a single photograph. In these cases, two photographs were taken, insuring that all four nails were visible in both photographs.

As with the photographic mapping process, the photograph of the profile is downloaded into Photoshop and processed in a similar manner. The main difference from the method of preparing the photographic map, the *Fixed Size* button dimensions are not equal. In the case of the 2009 Joya de Cerén field season, the values used were 15 x 5 cm, keeping true to the 3:1 ratio between the horizontal and vertical nail distances. The rest of the process, however, is virtually the same (Figures 7-5 and 7-6).

In the case of those profiles that have to be taken in two photographs, once each photograph has been processed individually, each should be cropped off at the same nail plane. The two photographs are then carefully joined by opening both within the Photoshop workspace and gradually moving them together and then erasing the point of junction with the *Healing Brush Tool* in order to minimize the visibility of the intersection between the two. In these cases, it is very important to insure that the initial image processing create a very distinct color or texture difference between the two photographs or it will be virtually impossible to hide the point of intersection.

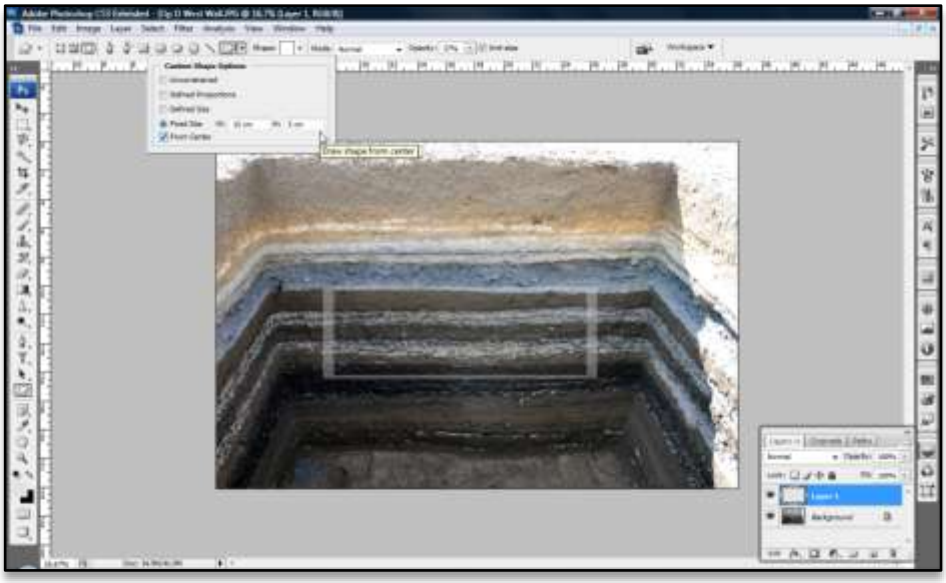

Figure 7-5: Adobe Photoshop CS3 Screen shot showing the custom shape tool dialogue box and the transparent box in place over the profile photograph.

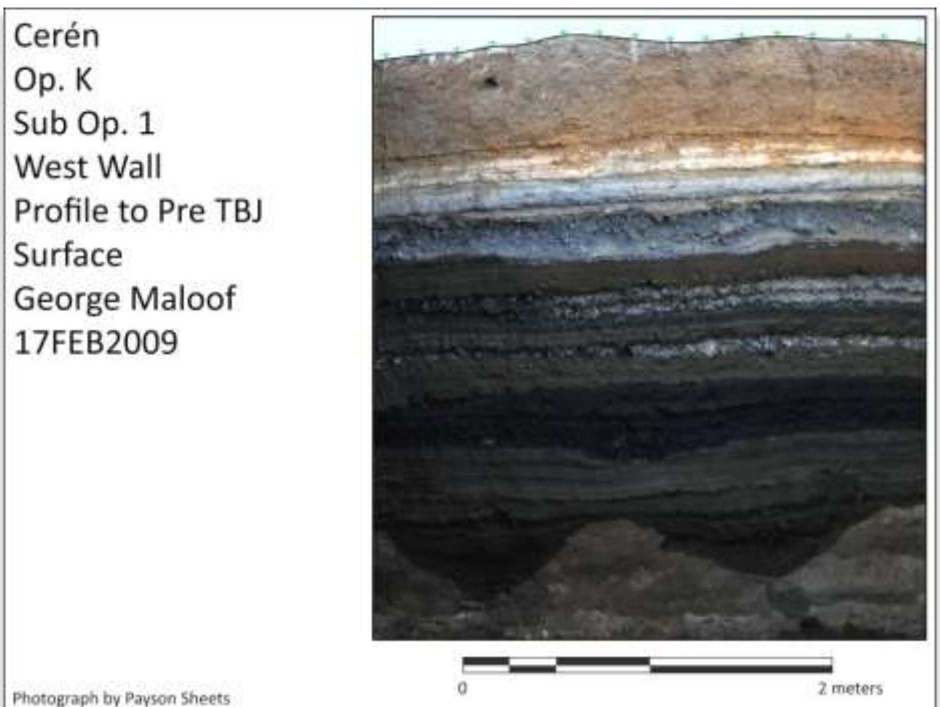

Figure 7-6: Example of a processed photographic profile.

Discussion

There are several advantages of photographic mapping and profiling over traditional methods. First and most important, the time needed to generate a photographic map or profile is a fraction of that of a traditionally drawn version. A traditional map or profile can take many hours to draw in the field and then hours more to digitize the final product. On the other hand, a photographic map or profile can take about 10 to 15 minutes to set up and then with experience another 10 to 15 minutes to process the photograph.

Secondly, the level of detail obtainable with a traditional drawn map or profile varies directly with the amount of time invested in its elaboration and the artistic ability of the artist. In contrast, a photograph records much more detail instantaneously, with the largest possible amount of information collected. Furthermore, in a drawn figure, the texture of a soil or feature can never be accurately drawn; the use of a representative symbol is the best that can be used (Alexander Zanesco, Personal Communication, May 2005) (Figure 7-7).

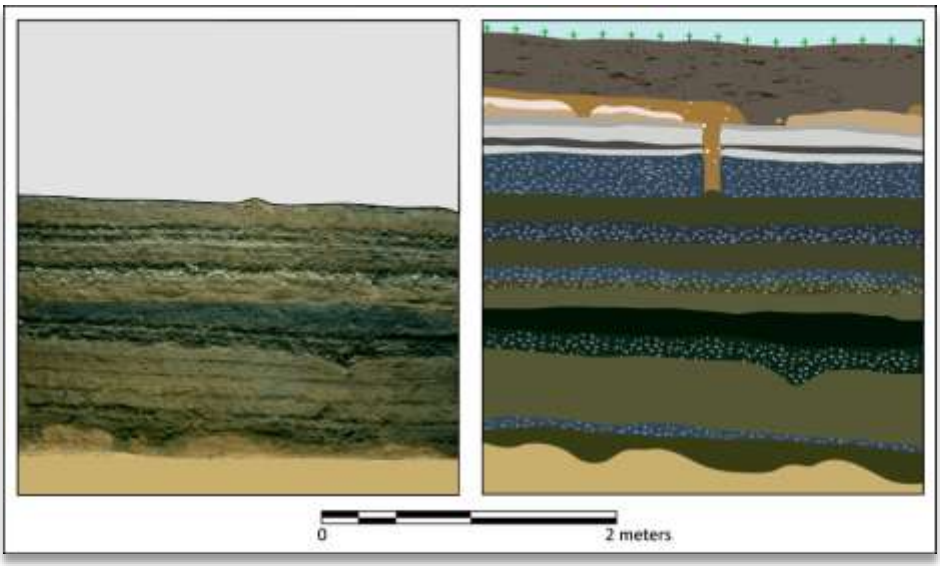

Figure 7-7: Comparison between a photographic profile and a conventional profile (west wall of Operation D, 2009 Joya de Cerén field season, photograph by Payson Sheets).

Thirdly, the accuracy of photographic maps and profiles is much higher than that of normal mapping and profiling in relation to the time spend it their production. In traditional mapping and profiling, the level of detail obtainable and the level of accuracy of a drawn map or profile are directly related to the amount of time invested in the production of the drawing and the number of points chosen for measurement during this process. In contrast, a properly processed photographic image can be every bit as accurate as a traditionally drawn figure if not even more so (Figure 7-8).

Finally, photographic maps and profiles can be much more versatile in their use in publications since a well taken photograph can be manipulated in a variety of ways in order to provide a better visual example, including the fact that they can be converted from color to black and white images very easily for inclusion in scientific journals.

Figure 7-8: Comparison between two photographic maps of Operation P at different stages of excavation. Photographs were taken at different angles by different cameras and different photographers (Left photograph by Payson Sheets, right photograph by Christine Dixon).

Conclusion

The use of digital photography in archaeology has revolutionized the collection of information at almost all levels of research. The possibility of seeing the photograph an instant after it has been taken has raised the quality of documentation and elimination of expensive photographic developing and printing has allowed archaeologists to increase the number of photographs taken during the course of research. Furthermore, user-friendly photo processing programs such as Adobe Photoshop have opened up avenues of photographic manipulation that once had been only available to highly-trained specialists. By taking advantage of the new tools that are available to the modern archaeologist, many novel techniques can be developed that will save both time and money throughout the course of a project. The use of photographic mapping and profiling is one of these ways that can improve the quality of the data being collected while maximizing the time available in the field. By improving the quality of the field data being collected, better interpretations can be made and mapping and profiling information can be much more effectively communicated with colleagues and the interested public.

Acknowledgements
I would like to thank the following people for their contributions to the development and polishing of this technique: first and foremost Dr. Payson Sheets for his encouragement and for being open to the idea of trying something new and having enough faith in my abilities to trust me using an untested technique for such an important aspect of the recording of information, Andrew Tetlow for his invaluable assistance in streamlining the field methodology for photograph preparation and for his assistance in laying out almost all of the photographic maps and profiles and finally Christine Dixon for asking all the right questions and insisting that photographic mapping could also be applied to plan views and the giant manioc furrows would not cause significant problems for the removal of distortion. I would also like to especially mention Rick Johnson and his article “Create a Photo Backdrop” that appeared in the September 2005 issue of *Model Railroader* magazine (vol. 72, no. 9). It was thanks to this article that I realized the capabilities of Adobe Photoshop and began to think of the application in my own work. Finally, I would like to give special thanks to Dr. Alexander Zanesco of the University of Innsbruck for without whom I never would have thought of the idea of using photographs in this way.

Chapter 8. Considerations, Summary and Conclusions.

Payson Sheets

Introduction

The origin of the 2009 research program was the discovery, in two test pits in 2007, of a manioc field that had been harvested and replanted (Sheets et al. 2007). That field was found over a hundred meters south of the Ceren archaeological site, on private land belonging to local farmers. The care with which the ridges were formed, and the calles between them maintained, were very impressive, and intriguing. Their size, some seven to ten times greater in volume than maize ridges, indicated that manioc was cultivated with greater care in the Classic period than at present. Today, the manioc that is grown for consumption is rarely planted in ridges, and is not carefully tended, but still yields considerable food per unit area. The range of manioc productivity today in El Salvador (production for consumption and for sale) is five to twenty five pounds of manioc tubers per plant, harvest weight (Ing. Miguel Quesada Perla, personal communication 2009). With 60 cm between plants, and 1m between lines of plants, or ridgetops, and a very conservative five kilos per plant, a 1-hectare field would produce 16,600 plants, or 83,000 kilos of harvested manioc tuber. Adjusting for the 65% water content of the freshly harvested tuber, the dryweight productivity would be 29,050 kilos per hectare. Our 2009 excavations confirmed manioc production over an area of about 1143 square meters, or 0.114 hectares. Thus the dryweight productivity of yuca in this area is estimated at 3312 kilos, or 3.3 metric tons. The care with which the ancient Maya cultivated their fields indicates their productivity per unit area may well have been higher than that. We do not know how much more was produced, because we have yet to find the northern or southern borders of manioc production.

It is hard to imagine a more important facet of any ancient culture than how they obtained their food. Archaeologists have been researching ancient Maya agriculture for many decades (see Chapters 1 and 4), and have had considerable success in finding large scale features such as terraces. However, smaller scale features such as planting beds and field boundaries have eluded detection, largely because so many factors of disturbance intervened between field abandonment and archaeological study. The area in and around the Cerén site is an important exception, as it is well preserved below the tephra of the Loma Caldera volcanic eruption of about AD 600.

The preservation provided by the eruption allows us to explore issues of importance in ancient agriculture. One issue is that of authority. Did the farmers of Cerén have the authority to make their own decisions within their fields? If they did, we should be able to detect significant individual variation in different fields. Or, at the other extreme, were they under the authority of the elite at nearby San Andres? If there was centralized authority affecting agriculture, we would expect a high degree of uniformity over a large area. That would mean we would find the pattern of manioc ridges and swales discovered in the 2007 test pits over a large area, with little variation. These issues come down to agency, i.e. who is making decisions, and how can the results of those decisions be detected in the archaeological record.

The result of the 2009 research is that individual cultivators apparently were making their own decisions within their plots of land. The boundaries of individual farmer's plots were visible where they terminated in cleared areas, in platforms, in other cultigens, or in two approximately parallel lines. Those two lines emanating from the village, at about 30 degrees east of north, operated as a land division mechanism, and are here called 'land use lines.' Those lines separated different kinds of land use, such as cleared areas, field platforms, manioc cultivation, and maize cultivation. If those lines were imposed by authority outside the village, such as from San Andres or other elite center in the Zapotitan valley, that would indicate a degree of land use control, from the top-down, that had not been documented before. However, it appears that those land use lines are from within the commoner community of Cerén, and probably were established by community discussions, village elders, as well as long tradition, and the deep-seated need of the Maya to orient themselves in their physical, mental, and spiritual environments. These land use lines do indicate authority higher than the individual farmer at any point in time, but apparently do not reflect authority from outside the community.

Methods

The methods of the 2009 fieldwork employed digging a total of 18 excavation pits, each measuring 3 x 3 meters, and about three meters deep (see Chapter 2 for details). Two of the pits were extended beyond those dimensions, to follow patterns and variation of particular importance. The detailed methodology is presented in Chapter 2. Three kinds of Classic period land use were encountered, cleared areas, cultivating manioc, and milpas where maize was cultivated.

Cleared Areas, and Land Use Lines

The cleared areas, described by George Maloof in Chapter 3, were found at the western and eastern ends of the research area, providing boundaries to the manioc and maize agricultural area in the middle. The excavations on the western side of the research area (see Figure 1-1 map: Operations A, B, C, W, M, and O) encountered the cleared areas, kept free from intensive farming and weed growth. An occasional volunteer manioc and corn plant were allowed to grow, and a few trees were growing there, but most ground surfaces were cleared, and some were deliberately leveled. Based on the evidence, we believe that these areas were used for the early stages of harvest, especially of the manioc that grew abundantly to the east. Here manioc was likely processed by separating the trunk from the tubers and possibly removing the cortex of tubers before slicing these into small sections for drying in the sun. Additionally, the farmers likely cut the bases of manioc trunks for replanting as they were re-shaping the surcos. The extensiveness of the cleared area and the efforts needed to maintain the space devoid of vegetation were surprising to us until we discovered the great magnitude of yuca growing immediately adjacent to the clear areas. Just prior to the Loma Caldera eruption, the yuca had been harvested essentially simultaneously. Large cleared areas would be needed for manioc processing, both for food and for the sticks utilized in replanting, called 'stakes'.

Manioc cultivation fields, and Land Use Lines

The manioc fields were the second kind of land use discovered and investigated, and they were found in the excavations ranging from Operations K and S and F in the south, to L and I and G in the center, to D and J and H in the north. It was indeed impressive to see such a large area devoted to a single crop, and of great importance that the entire area was harvested at the middle of the rainy season, probably in the month of August. Local people today inform us that a manioc bush can be harvested six months after planting, but productivity is better if growth continues for a few more months. Farmers state they prefer to wait nine to twelve months before harvesting.

The excavations into the manioc cultivation area helped resolve the question as to whether the fields were organized and controlled by elites, with procedures established over a large area, or whether individual farmers made their own decisions in their own plots. We found the latter. Some farmers created cultivation ridges for manioc that sloped inward toward the top, reaching a peak in the middle some 35 cm high. Other farmers created ridges with flat tops. Some farmers maintained straight and wide walkways (calles) between the ridges, while others preferred narrow and less regular calles. The different styles, and the boundaries of individual fields, were detectable in the excavations. The Maya farmers at Cerén had control over their families' fields, and cultivated them the way they wanted, without external higher authority telling them what to do and how to do it. Within their plot of land they had autonomy, and they exercised that autonomy.

Fascinatingly, we found another element of the organization of space that we did not expect. We found two lines, each running about 30 degrees east of magnetic north, which created boundaries within our research area. This is the same orientation of the household architecture and the public center of the village, and of the ridges in the milpas within the village. Thus the villagers extended that orientation south throughout our 2009 research area. The western line formed the boundary between the cleared areas and the manioc fields. The manioc fields were wisely placed where the hill sloped the most, over ten degrees, as manioc needs good drainage to give maximum productivity. An important research finding is that manioc was not just an occasional plant providing only a little food, but rather was a staple crop for the ancient Maya of Cerén.

The other land use line emanating from the village, following the same orientation and running down slope (closer to the river) from the other one, separated manioc on the west from maize on the east (found in Operations L, G, and E). The slope decreases to the east of this line, and it makes sense that maize would be cultivated there, as it needs more moisture than manioc to maximize productivity.

In Operation F to the south, this same eastern division line separated manioc of one cultivator from manioc of another cultivator. Their surcos and calles were formed differently, as they followed their own styles and standards. The cultivator had harvested but not replanted the western field, while the eastern field had been both harvested and replanted by the farmer.

Maize Cultivation Fields

The third general kind of land use encountered in the 2009 research was maize milpa, found down slope from the manioc, and east of the eastern division line. Maize was found on the eastern side of Operations L and G, and entirely within E. The density of planting, in terms of four or five seeds per locality, and the distances of planting localities along the ridges, is about the same as that previously found within the Cerén archaeological site. The substantial size of the maize surcos in these fields, as compared with those found with the site center is likely a function of position. These maize surcos are located at the base of manioc fields where significant amounts of water run-off during a rainstorm would create problems with erosion and crop damage. Thus the maize surcos in this region were likely built larger to resist erosion. Because the overall slope of the land decreases east of this eastern division line, allowing more infiltration of water, it is logical that cultivators switched from manioc to maize in this area.

Operation P: Cleared Area and Midden

The last excavation of the season, Operation P, was placed as far southeast as was feasible, to explore if cultivation of any crops extended that far. It turned out to be a cleared area, with no surcos, no weeds, and no deliberately planted crops. It had two volunteer manioc trunks, probably from the same tuber, and one volunteer maize plant. The area was marked by a large rectangular sun-dried adobe block that was oriented to 30 degrees east of north, and apparently formed a land division marker. Adjacent to it was a deliberately prepared surface, with tierra blanca joven carried in and smoothed out, perhaps functioning as an area for the *cosecha*, or harvest. The tierra blanca joven buried a trash deposit that is of considerable importance, as the organic preservation was excellent, and David Lentz and Angie Hood are continuing to study and interpret the beans, maize, and other organic materials from there.

Some of the artifacts found in the Operation P midden may have been involved with manioc harvesting and processing. The fact that such an extensive manioc cultivation area was harvested at the same time presents a challenge for understanding. Today, with modern transportation and marketing, extensive manioc fields can be harvested all at once and the tubers distributed widely to markets, many of them waxed for preservation. However, the ancient Maya must have used different techniques to handle the simultaneous harvesting of many manioc tubers. Traditional farmers in the Zapotitan valley, and their wives, may have provided an answer. In the early 20^{th} century and before, traditional agriculturalists, who did not have access to modern transportation or marketing, would dry and grind their surplus manioc tubers into a powder called 'almidon'. There is widespread agreement as to how that was done. The tuber first has the dark brown cortex removed by cutting a slice through it longitudinally and then peeling it off and discarding it. Then the white inside of the tuber is cut into segments some 4-5 cm long, and those are dried in the sun for eight days. Then the dried segments are pounded into smaller chunks and then ground on a mano and metate into the fine white powder called 'almidon.' That powder can be stored for many months without deterioration. It is possible that the fine white powder found in Structures 1 and 2 of Cerén were manioc 'almidon.'

Two tools found in the basurero of Operation P might have been used in manioc processing (see Chapter 5). Both are different from tools found within the village of Cerén. One is a basalt scraper with extensive use wear on the edge. The other is an obsidian prismatic blade with considerable abrasion parallel to both edges, with significant wear on one of those edges. This is the type of use wear that would develop on a prismatic blade used to remove the cortex of a somewhat gritty manioc tuber. Thus, these two artifacts from Operation P might be the first recognizable evidence of ancient Maya tools used for processing manioc.

Conclusions

In summary, the 2009 research into the ancient Maya agriculture south of the village of Cerén made some important discoveries. We found a relatively high level of spatial organization that not only dominated most orientations of architecture and cultivation within the village, but extended well south of the village, through our 2009 research area. How far beyond that is unknown. That orientation, 30 degrees east of north, apparently was set for the village by the orientation of the entrenched river nearby, again showing the importance and reverence the Maya had for water. A higher principle of organization, dominating cultivation from above, such as from an elite center, was not found. Rather, it is apparent that individual cultivators had and exercised considerable freedom of choice in how they planted, cultivated, harvested, and replanted their crops within their particular plots of farmland.

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