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# Mapping and Radiocarbon Dating Archaic Period Monuments: La Alberca Structure Complex, Highland Michoacán, Mexico

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MAPPING AND RADIOCARBON DATING ARCHAIC PERIOD MONUMENTS: LA  
ALBERCA STRUCTURE COMPLEX, HIGHLAND MICHOACÁN, MEXICO

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A Thesis

Presented to

The Graduate Faculty

Central Washington University

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Resource Management

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by

Mark F. Steinkraus

June 2016

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

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Dean of Graduate Studies

## ABSTRACT

### MAPPING AND RADIOCARBON DATING ARCHAIC PERIOD MONUMENTS: LA ALBERCA STRUCTURE COMPLEX, HIGHLAND MICHOACÁN, MEXICO

by

Mark F. Steinkraus

June 2016

Ongoing collaborations with the Comunidad Indígena de Nuevo San Juan Parangaricutiro hold great potential for exploring the origins of sedentary ranked communities that predate others in Mesoamerica by as much as one thousand years. Three carbon samples from the lower buried portions of the Central Structure at La Alberca Complex yield a date range of 7245-6470 cal B.P. The carbon sample laying on an upper tier of the feature yields a date of 4780 cal B.P. These dates suggest that the feature is 7000 to 6000 years old and may have been in use as recently as 5000 to 4000 years ago (in calibrated radiocarbon years). These radiocarbon dates fall in sequence and overlap the dates for the burial in the nearby La Alberca Rockshelter (6650 -3985 cal B.P.). The Central Structure as well as above ground Structures 1 and 5 (labeled *Yacata*) are buried below a coarse consolidated tephra. Although more weathered, this tephra is similar to the oldest tephra in the bottom of La Alberca Rockshelter. The tephra is at least 7000 to 8000 years old (calibrated).



Test trenching and probing, when combined with 3-D ArcMap visualization, reveal important details about the fully buried Central Structure. It appears to have been built on top of, rather than into an elevated natural landform. It is ovoid in shape (24x32 meters, with a NE-SW orientation) and three meters in height. The structure was built using three tiers formed from rock walls backfilled with sediments to create gently sloping steps or terraces. The middle tier is consistently five meters in width. Each tier is between 60 and 90 cm high. Configuration of the surface and first tier of stones suggest that the structure has been robbed of stone for fence building, tree planting, and/or field clearing. The Central Structure is devoid of artifacts apart from the one concentration of resinous charcoal dated to 4780 cal B.P. The earliest ceramic sherds recovered from the Structure Complex (50-80 centimeters deep) are found above the lower tephras (1-2.5 meters deep) that superimpose rock construction.

The Central Structure and Structures 1 and 5 (Yacata) are the oldest known stone and earth structures in West Mexico. They are most likely precursors to the Late Formative *guachomontanes*, and may cover burials if not shaft tombs. West Central Mexico is now identified as home to the closest genetic relatives to maize and beans and includes the earliest archaeological evidence for maize. It follows to hypothesize that sedentism, social ranking, and ritual structures would also develop very early within this region. The Late Archaic ritual burial in La Alberca Rockshelter and the earlier structures of the La Alberca Complex predate similar developments in the Early Formative Period in West Mexico. The burial and preservation of ritual structures in the Parangaricutiro Highlands by tephra from several eruptions provides challenges for both geoarchaeologists and

tephrochronologists hoping to refine models of the nature and extent of the influences of volcanoes on early cultural developments.

Key Words: Late Archaic, Early Formative, Archaeology, Earthen Structures, Tephrochronology, Central Mexico, and Parangaricutiro Highlands.

## ACKNOWLEDGEMENTS

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I would like to thank the Parangaricutiro Community who have shared their homes and culture with us over many years. Thank you to Ambriso Aguilar, Leopoldo Ventura Aviles, and their families for allowing us to conduct this important work on their land. Thank you to the Instituto Nacional de Antropología e Historia (INAH) as well, for granting us permission to conduct archaeological investigations in this area (under permit number C.A. 401-36/1306). I would like to extend a special thank you to Tricia and Narcizo, without you two none of this would ever have been possible. Dr. Tricia Gabany-Guerrero sadly left us during the course of my thesis work, and she is truly missed. This thesis is dedicated to her legacy and memory.

Many thanks to my family and friends who helped me with all of life's ups and downs through this process. I would also like to thank all of the previous MEXECRI volunteers and students and all of those who have contributed to previous work in this area. Your time and dedication helped make this thesis possible. Finally, thank you to Ansel DeLeon for the countless hours and days you spent helping me with this project. I truly appreciate all the work you did.

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## CHAPTER I.

### INTRODUCTION

La Alberca Structure Complex, an extensive complex of monuments in central Michoacán, Mexico was first identified by a collaboration of researchers from Central Washington University (CWU) and California State University-Fullerton (CSU-F) in the summer of 2000 (Figure 1). This research was conducted under a permit from Instituto Nacional de Antropología e Historia (INAH), permit number C.A. 401-36/1306 (Gabany-Guerrero 2007).

The complex is composed of at least sixteen monuments. Locally these monuments are referred to as *yacatas*. In west Central Mexico *yacatas* range in size from small mounds to massive stone “pyramids.” Most of the derivation is from the Purépechan word “*yacatani*” which means “to heap up stones with mud” (Pepper 1916: 415). Most documented *yacatas* date to the Post Classic Period.

The major focus of my thesis research has been on the Central Structure. This buried rock feature was first discovered in 2007. Our team, including the author, hand excavated a trench over the Central Structure and found that the feature extended from a few centimeters below the surface to deeper than 2.5 meters. This structure first named the Buried, or the Central Stacked Rock Feature, yielded a carbon sample that was collected and dated to 6160 ±40 BP. Fieldwork conducted in June of 2009 included mechanical backhoe trenching and total station mapping. In June 2013 I returned to the site and conducted further GPS mapping and probe resistance depth mapping.

Examination and analysis of data gathered in these site visits is the focal point of my research.



**Figure 1. Map of Michoacán with the Parangaricutiro territory highlighted as black (adapted from Guerrero-Murillo 2006).**

## Problem

To date, very little has been published on Pre-Formative peoples of western Mexico, particularly those of the highland regions (Beekman 2009; Zeitlan 1984). Traditionally, researchers have focused their efforts on the later classical societies of the Tarascan and Aztec Empires, leaving much of what came before these civilizations a mystery. Beekman (2009), summarizes current archaeological sites in western Mexico and points out some of the data gaps in the current research. Beekman states that there are no definite Early Formative (2000-300 B.C.E.) settlements that have been investigated as yet; however, the western highlands include remarkable mortuary features that express control of land by lineage based corporate groups. There is a clear need for researchers to publish on theoretical topics such as the early origins of Archaic and Early Formative monumental structures in the highlands of Western Mexico.

## Purpose

The overall goal of my thesis is to contribute to investigations of public monuments within the uplands of Western Mexico. The three objectives of my project are: analyze stratigraphic evidence, evaluate radiocarbon dates, and complete 3-D visualization for the Central Structure. In this thesis I report the results of test excavations including the interpretations of tephrochronology at the site conducted during previous surveys. From this data I created a model of the Central Structure and the stratigraphy surrounding this feature. Examination of the Structure Complex provides a unique opportunity to significantly increase our understanding of the origins of monumental

architecture and how these structures may have changed over time. This will be accomplished by addressing the research questions of this thesis.

### Significance

La Alberca Structure Complex is highly significant and deserves more intensive study. Very little is known about the Early, Middle, and Late Archaic periods of the Central-West Mexican highlands. The stacked boulder feature I am focusing on (the Central Structure) is located within La Alberca Structure Complex and positioned at the site's center. Drozdowski has demonstrated possible astronomical alignments of structures within the site (Drozdowski et al. 2013 and 2015). Interpreting the Archaic Period Central Structure and how it relates to the surrounding features may shed light on the development of early public structures and may draw links to early sacred geography at other sites (Marcus and Flannery 2003). This site also has the potential to yield information regarding the early development of ranked societies among agricultural communities (Buckler et al. 1998; Lentz et al. 2001; Piperno and Flannery 2000; Rue 1989).

### Research Questions

- 1) What is the stratigraphy of La Alberca Structure Complex and related sites?
- 2) What is the age of the Central Structure in comparison to the other structures found at the Structure Complex and in relation to La Alberca Caldera Rockshelter?
- 3) What is the shape of the Central Structure? What hypotheses can we form about the function of the Central Structure?



## CHAPTER II.

### LITERATURE REVIEW

There are few scholarly sources that examine sites that are similar to La Alberca Structure Complex. The focus of the overall body of literature from Latin American archaeology has primarily been “cultural-historical” with focuses on the Formative and Classical societies (see Table 1), ceramic typologies, and art forms (Beekman 2009). There appears to be a bias in the literature where documented Archaic sites are greatly outnumbered by other types of sites. This could possibly be explained by lack of research interests, depth at which these site types are discovered, and/or a general belief that nothing noteworthy was going on during this time frame in the region of study (Beekman 2009; Gabany-Guerrero 2011; Zeitlan 1984).

**Table 1. Timeline of cultural periods (adapted from Beekman 2006).**

<b>Time Period</b>	<b>Time Range</b>
Paleo-Indian	11000+ B.C.E.
Early and Middle Archaic Periods	11000-5000 B.C.E.
Late Archaic	5000-2000 B.C.E.
Early and Middle Formative Periods	2000-300 B.C.E.
Late Formative and Early Classic Periods	300 B.C.E.-500 A.D.

#### Prehistory of Western Mexico

The Paleo-Indian as well as the Early and Middle Archaic Period (11000 to 5000 B.C.E.) have the earliest evidence for human activity for the region (Beekman 2006).

Life during this period is generally characterized by nomadic hunting and gathering lifestyles, with artifact assemblages consisting primarily of lithics associated with hunting practices (MacNeish and Nelken-Terner 1983). It is believed that by the Late Archaic Period (5000 to 2000 B.C.E.) climate changes were occurring from cold and wet to warm and dryer conditions (Buckler et al. 1998). It is during this time that early plant and animal domestication was being attempted (Beekman 2006 and 2009). This allowed for a transition to sedentism and the construction of monumental structures (Beekman 2009; Blomster 2010; Marcus and Flannery 2003).

Archaic evidence of early structures so far have been associated with nearby coastal populations who subsisted on maritime resources and, perhaps, present the earliest evidence of social complexity within the western hemisphere. The earliest materials are a small collection of artifacts associated with a dated shell mound (2850-2200 B.C.E.) on the Late Archaic coast of Nayarit (in the neighboring state of Jalisco to the north) called the Matanchen complex (Mountjoy 1970). The site has been interpreted as a food-extraction station in which the shell mound is nothing more than a shell midden (Kennet and Voorhies 1996). There is another shell mound dated to a slightly later time (2250 B.C.E.) located at Cerro el Calón in the mangrove swamps of the Marismas Nacionales to the north (50 miles south of Mazatlan). This 23 meter high mound is composed of unopened *Anadara grandis* (brackish water clam) and other shells; its construction serves an unknown purpose (Scott and Foster 2000).

Further to the south on the Chiapas coast there is another intentionally created shell mound at Alvarez del Toro which has multiple cement floors and dates to over 3000

B.C.E. (Beekman 2010). These mounds suggest ceremonial platforms of some kind, although other evidence is sparse. According to the literature this suggests that some of the earliest complex developments may have occurred on the Pacific coastal plains. These coastal mounds, however, date 1000 years after the initial dates for La Alberca's Central Structure located in the highlands (Hackenberger and Gabany-Guerrero 2010).

The Formative period is characterized by many researchers as the origins of early plant cultivation and intensive agricultural sedentary societies (Blake 1992; Blomster 2010; Buckler et al. 1998; Lentz et al. 2001; Piperno and Flannery 2000; Rue 1989). The spread of domesticated crops begins in the Late Archaic period in western Mesoamerica (Blake 2006). Deforestation in the Zacapú basin of northern Michoacán was noted by 4000-3600 B.C. (Arnauld and Faugère-Kalfon 1998). Maize pollen has been noted in lake cores from the Pátzcuaro basin as of 1690-940 B.C.E. (Bradbury 2000), the southern Nayarit by 1900-1300 B.C.E., and the southern Bajío by 1300 B.C.E. (Brown 1984, 1985; Stuart 2003). The closest genetic ancestor to maize is the wild *Zea mays parviglumis* found in the Balsas Depression. The second closest wild relative of maize comes from southern Jalisco (Doebly et al. 1990). The genetic ancestor to the common domestic bean is the wild bean of highland Jalisco (Smith 2001).

Blomster (2010) explores the sociopolitical organizations and interactions between Early Formative societies in the neighboring state of Oaxaca, particularly that of the Olmec. Blomster created a model for how Early Formative societies may have interacted with one another, though his argument is based primarily on ceramics. Blomster's work provides a brief description of elite and commoner households of the

Early Formative period. The elite households were built up a meter high atop rubble mounds and sometimes had plaster walls or sculptures, while commoner housing was built at ground level around these elite structures.

Beekman (2008) looks at how corporate power strategies may have shaped the societies of the Late Formative to the Early Classic periods. Beekman uses the example of Tequila Valley located in Central Jalisco (the neighboring state to the north). The sites excavated have no clear elite housing or palaces but they do have shaft tombs and public structures called *guachimontones*. These structures are always round in shape and sometimes have shaft tombs underneath them. *Guachimontones* were usually constructed of boulders and earthen rubble and they varied in size (Faugère and Darras 2005). Some localities show numerous *guachimontones* which were constructed, however, differences in construction techniques suggest that they were being built and up-kept by lineages and not by individuals. Beekman believes the monuments represent a competitive ritual tied to status rivalry between lineages. These *guachimontones* found in the Late Formative period are very similar to the Archaic Period mound structure located within La Alberca Complex. It is possible that the Central Structure could be an early example of this type of monument.

### Regional Environment and Tephrochronology

The study area falls within the Parangaricutiro Highlands (Highlands) in the state of Michoacán in central western Mexico (see Figure 1). This area is controlled by an indigenous community (the Comunidad Indígena de Nuevo San Juan Parangaricutiro) much like Native American Reservations in the United States. This “reserved” land or

cultural territory encompasses over 150 square kilometers and was only recently reincorporated to its indigenous people the Purépecha in 1981 (Guerrero-Murillo 2000).

The Purépecha people are the descendants of a large postclassic civilization previously called the Tarascan Empire (1000-1525 C.E.), which was the primary rival to the Aztec empire in western Mexico (Gabany-Guerrero 2007). The origins of the Purépecha remains unknown, however the name *Purépecha* means “new arrivals” or “late comers” which suggests that they may have originated from elsewhere and established a new home in this region (Malmström 1995; Schmal 2004). The Purépechan civilization was primarily centered at three sites near Lake Pátzcuaro: Sapacu Angamuco, Pátzcuaro, and Tzintzuntzan, with Tzintzuntzan being the capital city of the Purépecha Empire (Beekman 2009; Fisher et al. 2011).

This Parangaricutiro Highlands are dominated by forested mountains and open valleys spread over the Michoacán-Guanajuato Volcanic Field, a volcanic terrain with approximately 1000 volcanoes (Newton 2005). This includes Paricutin which erupted in 1943 causing the relocation of the indigenous community of San Juan to its new location (Espíndola et al. 2000; Luhr 2001; Telford 2004). The high altitude zones and aquifers have provided an ideal environment for past and present human habitation due to the presence of springs, caldera ponds, wildlife, and pine-oak (*Pinus* and *Quercus* sp.) forests (Figure 2).



**Figure 2. Overview of vegetation and topography of the surrounding area of the study area.**

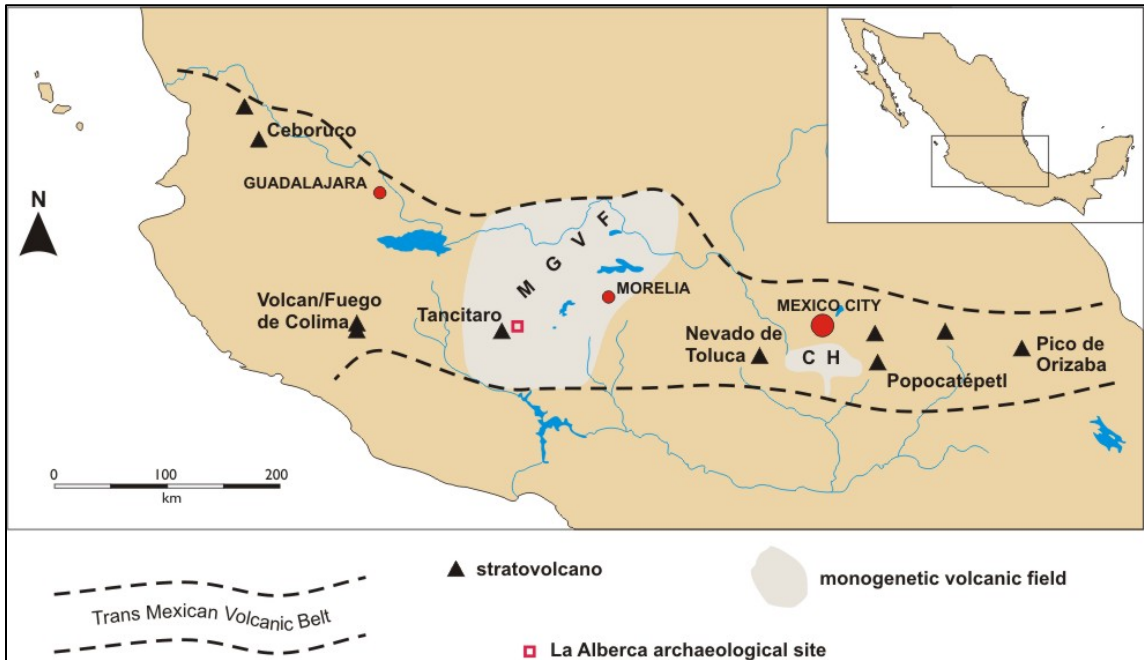
The soils for the study area are predominantly volcanic in nature with depths ranging from 20 centimeters to 10 meters. The soil colors fall into brown, yellow, and red categories. Their structures are generally permeable and textures include sandy, loamy, and clayey soils with a generally acidic pH (Guerrero-Murillo 2000). The soils are classified into several groups: andisols (recently derived soils from volcanic ash), phaeozem (soils rich in organic material found in the valleys and hillsides), and cambisols (soils characterized by high content of swelling-type clays) (Valadez and Porras Mas 1978).

Studies have been conducted near the project area that focus on environment change (Espíndola et al. 2000; Luhr 2001; Metcalf et al. 2006; Newton 2009; Telford et al. 2004). In the general project region gradual drying and increased climatic variability started to occur in the early Holocene. By approximately 4000 cal. B.P. the modern summer regime was in place (Metcalf et al. 2006). The first agricultural patterns in this area were noted as the climate warmed and became more arid (occurring between 6500 and 4000 B.P.)(Buckler et al. 1998).

The project area lies within the Trans Mexican Volcanic Belt (TMVB) which stretches for 1100 km across central Mexico. Volcanoes in this region are mainly Quaternary and currently a series of large stratovolcanoes are scattered across central Mexico (Newton 2009). Volcanic activity in Michoacán is different from the overall TMVB, as it is dominated by numerous small monogenetic cinder cones as opposed to large stratovolcanoes. This area forms the Michoacán-Guanajuato Volcanic Field, which is marked as MGVF on Figure 3. These cinder cones along with stratovolcanoes and their predecessors have erupted numerous times depositing volcanic ash or tephra layers throughout the region (Figure 4). When identified and dated these tephra layers form invaluable depositional markers (Newton 2009).

Newton's tephrochronology research in particular is the most relevant. Newton examined and created a climate model from Tephra samples that came from the nearby and possibly associated La Alberca Caldera site, a rockshelter/burial. This site has overlapping stratigraphy with La Alberca Structure Complex, but their samples do not date back further than 2400 years B.P. From his research it appears that there have been

several climate warming and cooling trends over time and on average two volcanic eruptions every 1000 years. These eruptions can account for the volume of tephra deposited on La Alberca Structure Complex.



**Figure 3. Map of the Trans Mexican Volcanic Belt (Newton 2006).**



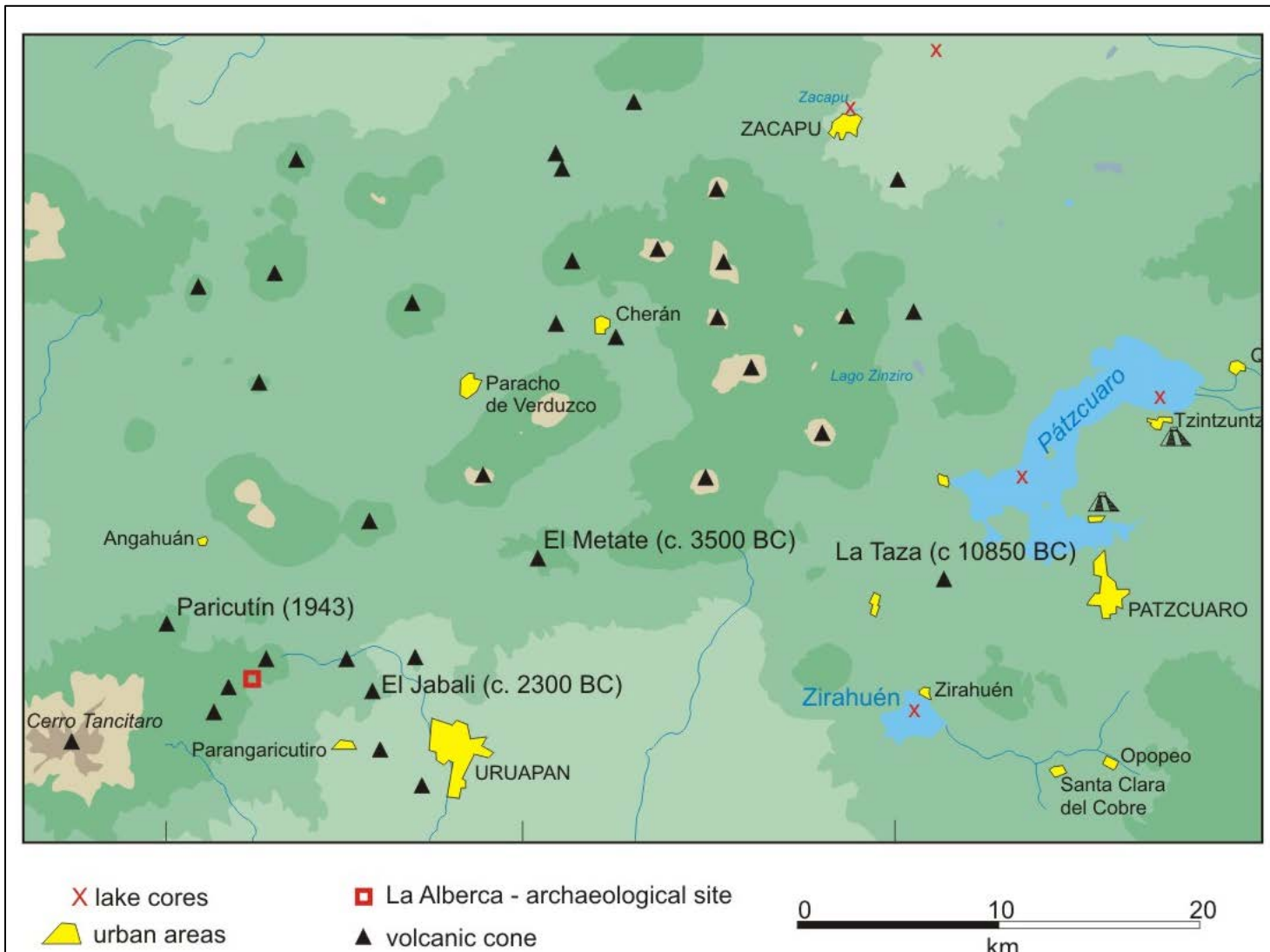


Figure 4. Map of volcanic cones around La Alberca from Newton (Newton 2006).

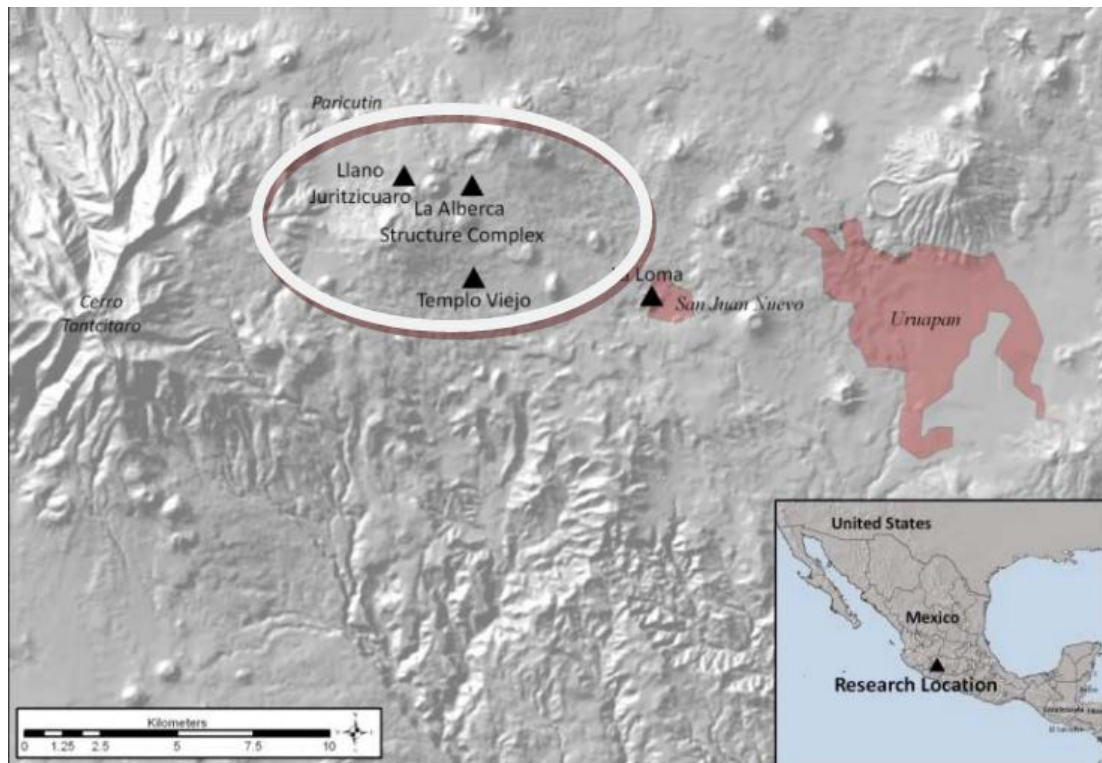
## CHAPTER III.

### PROJECT HISTORY AND LA ALBERCA ARCHAEOLOGY

This section presents an overview of the timeline for the projects developed as part of the Parangaricutiro collaborations. The section also includes background information for the La Alberca Structure Complex and Caldera Rockshelter . The stratigraphy and tephrochronology are outlined. A pilot magnetic susceptibility analysis is reported. A summary of the ground penetrating radar project also helps to provide context for my study of the Central Structure.

#### Study Area: La Alberca Structure Complex

La Alberca Structure Complex (see Figure 5) is situated high in the mountains at the base of a massive cinder cone called Pario. The site is located in a somewhat remote region where archaeological sites have been under-researched. La Alberca Structure Complex consists of more than a dozen stacked rock mounds of varying sizes (5-25 meters), called *yacata*, spread over a square kilometer. The site is located primarily in a pine-oak forest and overlaps partially with cow pasture/agricultural fields that are actively utilized by modern indigenous people. Access to the site is somewhat restricted to the public due to the fact that it is in the middle of the Purépecha owned and protected Highlands, and there is a manned gate controlling access to the main road used to approach the site. Excavations at the site were conducted under the supervision of the Instituto Nacional de Antropología e Historia, in accordance with Mexican Law (Gabany-Guerrero 2007).



**Figure 5. La Alberca Structure Complex locator map in reference to other important archaeological sites from the region (Hackenberger and Gabany-Guerrero 2010).**

Six separate archaeological surveys, from 2005 to 2013, have been conducted at the site, these include terrestrial and subsurface surveys (Table 2). All surveys were conducted in joint by Dr. Steven Hackenberger of Central Washington University (CWU) and Dr. Tricia Gabany-Guerrero of California State University-Fullerton (CSU-F).

To date sixteen structures have been identified, mapped using the global positioning system (GIS), and test excavated within La Alberca Structure Complex (see Table 3). Not much is known about the culture that inhabited and built the structures at the site but radiocarbon dates from Yacata 1 and the Central Stacked Rock Feature indicate multiple phases of construction at the site, ranging from the Late Archaic to the Formative Period (see Table 1).

**Table 2. Project timeline from 1999 to 2013.**

<b>Year</b>	<b>Activities</b>	<b>Presentations</b>	<b>Manuscripts-Reports</b>
1999			Gabany-Guerrero 1999
2000	Pilot GPR Projects		Guerrero-Murillo 2000
2001	<b>FAMSI GRANT</b> La Alberca Caldera Rockshelter Mapping and Burial Recovery		
2002	<b>NAT. GEOGRAPHIC</b> Rockshelter, Pictograph Inventory, Caldera Trenching		
2003	Caldera Trenching		Gabany-Guerrero 2003
2004			Gabany-Guerrero 2004
2005	Preliminary Survey Work at La Alberca Structure Complex		Gabany-Guerrero 2005a Gabany-Guerrero 2005b
2006	La Alberca Structure Complex Survey, Mapping, and Testing	Chatters 2005 Buswell 2006 Hackenberger & Gabany-Guerrero 2006 Hackenberger, Gabany-Guerrero & Guerrero-Murillo 2006 Newton 2006 Trosper et al. 2006	Newton 2006 Trosper 2006

**Table 2. Project timeline from 1999 to 2013.**

<b>Year</b>	<b>Activities</b>	<b>Presentations</b>	<b>Manuscripts-Reports</b>
2007	La Alberca Structure Complex Mapping and GPR, Deep testing rock feature	Bertolani et al. 2007	Gabany-Guerrero 2007 Gabany-Guerrero et al. 2007
2009	La Alberca Complex mapping and deep trenching	Chatters 2008 Ellering 2008  Hackenberger 2008a and 2008b Hackenberger & Gabany-Guerrero 2008 Liu et al. 2008	Liu et al. 2008
2010	La Alberca Complex testing and Preliminary Mapping Juritzicuaro (Plain of Jars) Archaeoastronomy	Gabany-Guerrero et al. 2010 Hackenberger & Gabany-Guerrero 2010 Huntington et al. 2010 Steinkraus et al. 2010	
2011		Gabany-Guerrero & Hackenberger 2011	
2013	La Alberca Structure Complex Archaeoastronomy	Drozdowski et al. 2013 DeLeon et al. 2013 Gabany-Guerrero & Guerrero-Murillo 2013 Hackenberger & Gabany-Guerrero 2013	Gabany-Guerrero & Guerrero-Murillo 2013

**Table 3. Summary of monumental features within La Alberca Structure Complex (adapted from Hackenberger 2005-2016).**

<b>Location Structure</b>	<b>Shape</b>	<b>LxWxH (m); Est Vol (cu m)</b>	<b>Cover/Exposure</b>	<b>Stratigraphy</b>
Structure 1 formerly Yacata 1	Circular- Oval	25x25x4; 500	Mature pines; 5 m trench on S 3 or 4 tiers with boulders; starting 15 meters further S a 15 m trench includes boulders at 4-6 m 1 m deep; probes also reveal a 2 <sup>nd</sup> set of boulders at 8-9 m 1.5 m deep.	Paricutin & Mottled (0-80 cm); Weathered Orange T in 2 strata (80-180cm); Brown T (180-240); Gray/Pink T consolidated & Coarse Brown T in pockets (240-280cm)
<i>Cejocope</i> Tree Rock Feature.	Unknown	Unknown	Buried, SE section of stacked boulders 2-4 m deep; exposed boulders 2x2x2	
Central Structure Formerly Central Rock Feature	Oval - Rectangle	25x25x3; 400	Buried, 5 trenches exposed 3 tiers of boulders and slabs; the lowest tier is 2.5 m deep on the S side	Paricutin & Sediment (0-80 cm); Weathered Orange T (80-120/180cm); Gray Consolidated T (120/180-250 cm); Gray Uncon. T over boulder (200-250cm)
Rock Feature. 2	Disturbed Ring		Looted area 10 m diameter exposing buried boulders	No obvious stratigraphy some ceramics & obsidian
Structure 5 formerly Yacata 5 (YL)	T or L Shaped; w/ tail	35x20x4; 600-800 w/ tail	Mature pines on crest; S side 3 m trench, all sediment to boulder base; T-L shape due to looting associated w/ large pit to NE?	Paricutin & Mottled (0-73 cm); Weathered Orange T (73-115cm); Gray Consolidated T (115-140); Uncon. T over boulder (140-150cm)
Structure 6 formerly Yacata 6	Oval or Teardrop; w/tail	30x20x2; 600-800 w/tail	E. tail 6 m. trench, 50-100 cm to rock rubble surface	

**Table 3. Summary of monumental features within La Alberca Structure Complex (adapted from Hackenberger 2005-2016).**

<b>Location Structure</b>	<b>Shape</b>	<b>LxWxH (m); Est Vol (cu m)</b>	<b>Cover/Exposure</b>	<b>Stratigraphy</b>
Rock Feature 3 Formerly Foundation	Rectangle	8x8x.3; 20	Buried-trenched, Boulder foundation traced from looted area (10x12 m)	Foundation like alignment of boulders 20-30 cm deep enclose an area 8x8 m
Structure 4 formerly Yacata 4	Oval	30x20x1.5; 300	Mature pines, cut	
Structure 3 formerly Vertical Rock Slab on mound (YB)	Oval	20x10x1.5; 200-300	Mature pines, cut; Boulder alignment on E and vertical slabs at SE point of structure (azimuth 110)	
Structure 8 formerly Yacata 8	Tear or Pare-like; w/tail	40X20x4; 2,400	Large oak w/ historic rock wall on spine SW-NE of structure; No exposure but dozed pasture to E.	
Structure formerly Yacata 9	Oval	20x10x1.5; 200	Mature pine, cut; No exposure	
Structure 10 FormerlyYac ata 10 New- Largest	Circular	40x40x4; 3,200	No exposure; mature oak recently cleared	
Structure 7 formerly	Oval	30x15x1.5; 360	E edge truncated by road cut with rock retaining wall	

**Table 3. Summary of monumental features within La Alberca Structure Complex (adapted from Hackenberger 2005-2016).**

<b>Location Structure</b>	<b>Shape</b>	<b>LxWxH (m); Est Vol (cu m)</b>	<b>Cover/Exposure</b>	<b>Stratigraphy</b>
Yacata 7 (NY)				
Structure 11 formerly Yacata 11	Circular	10x10x1.5; 150	Mature pine; N side 2 m trench 2-3 tiers of boulders	50-100 cm top soil over boulders; Unit to E. Gray Consolidated T at 1 m
Structure Formerly Yacata 12	Oval	20x10x2; 300-400	Mature oak; Deep looting on N side	Sediment to 1.5 m; charcoal at 1.5 m; Gray Consolidated T at 2 m
Structure 13 formerly Yacata 13 originally yacata 1	Circular to Oval	15x10x2; 150-200	Mature oak; Looting in center deepened	Sediment to 1.5 m Charcoal sample yacata 1 at 1.5 m (dated 800 B.P); Large boulders 180 cm
Structure 14 formerly Yacata 14	Oval	15x10x3; 150-200	Mature oak; Looting in center, on E. side and NE corner	Profile NE corner: Sediment (0-80 cm); Orange Weathered T (80- 160); Gray Consolidated T four strata (160-240 cm); Gray Unconsolidated T (240-280 cm)



La Alberca Structure Complex has good site integrity and is relatively well preserved, preliminary radiocarbon dates suggest extreme antiquity of the site, along with the high density of artifacts and features this complex provides an optimal location to study Middle Archaic-Early Formative Period settlements and their political and architectural systems in the western Mexican highlands (Hackenberger et al. 2006, 2010b).

Early fieldwork conducted on the site began in 2005, when seven mounds were identified and mapped during a pedestrian survey and a grid was laid out and investigated using ground penetrating radar (GPR). No features were located by GPR at this time. The Central Stacked Rock Feature, the focus of this thesis, was first identified by the field crew (including the author) during test excavations in 2007 (see Methods Section for more information).

#### Comparison Site: La Alberca Caldera Rockshelter

Approximately 500 meters to the north of La Alberca Structure Complex is La Alberca Caldera Rockshelter, the only other known archaic site within the region (Figure 6). La Alberca Caldera Rockshelter is located twenty meters above the floor of a caldera and directly across the caldera from a freshwater spring. The rockshelter itself is approximately 30 meters in length and four meters in width and is surrounded by dozens of anthropomorphic/ zoomorphic figures and zig-zag pictographs created using red pigment.

Directly under these pictographs the remains of what may have been an Archaic Period shaman were discovered entombed with large slabs of rock (Chatters 2005, 2008;

Gabany-Guerrero et al. 2015). The burial at the rockshelter dates to approximately 3000 years after the oldest date from the Stacked Rock Feature (see Table 4) (Hood 2009). Many samples of sediments have been collected and profiled from both locations. Associated organic components found within or between strata were used for  $^{14}\text{C}$  dating.



**Figure 6. Locator map for La Alberca Structure Complex and La Alberca Caldera Rockshelter sites.**

**Table 4. Radiocarbon results from Caldera Rockshelter. Samples were tested by Paleo Research Institute, Golden, Colorado. Stafford Laboratory processed sample 177073 for AMS, at the University of Wisconsin, Madison, Wisconsin.**

<b>Sample #</b>	<b>Description</b>	<b>Conventional Date</b>	<b>2-sigma Calibrated Date</b>	<b>13C (0/00)</b>	<b>N15/N14 (0/00)</b>
213893	Stratum 8 - Charcoal sample from deepest pit under burial boulder	7840 +/- 70 BP	7030 - 6860 BC	-12.5	
206455	Stratum 5 - Charcoal sample directly under burial boulder	5750 +/- 40 BP	4700 - 4490 BC	-23.4	
348	Stratum 5 - Partially burned charcoal in fire pit beside (east) deer antler under burial boulder	5680 +/- 20 BP	4550 - 4455 BC	-23.3	
177071	Stratum 4 - Charcoal sampled from fire pit at same level as burial, 15 cm west of burial spinal remains	4680 +/- 40 BP	3620 - 3580 BC	-26.2	
177073	Stratum 4 - Human femur from burial	3760 +/- 40 BP	2560-2520 BC	-14	+7.4
177072	Stratum 4 - Human tibia from burial	3960 +/- 40 BP	2570 - 2340 BC	-14.3	
UCIAMS-19324	Stratum 4 - Tooth #9	3890±20 BP	2464-2332 BC	-5.4	
UCIAMS-19334	Stratum 4 - Tooth #9 duplicate	3915±15 BP	2470-2390 BC	-4.0	

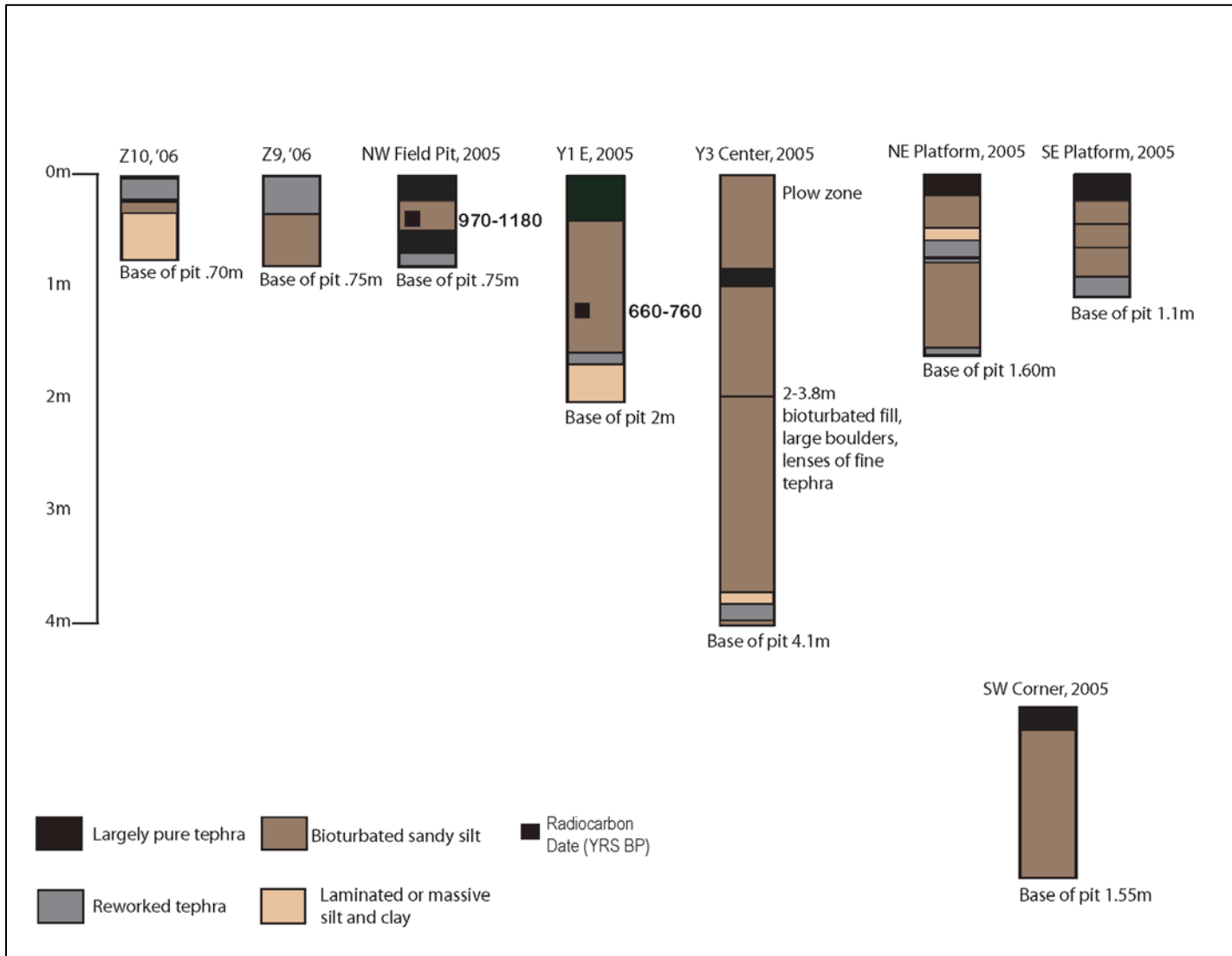
## Stratigraphy and Tephra

Documentation of the stratigraphic record of La Alberca Structure Complex and surrounding sites grew with each field session between 2005 and 2013 see Figure 7 (Trosper 2006). In addition to excavations in the Rockshelter (Figure 8) and geological trenching in the Caldera (Figure 9), profiles were documented and sampled from road cuts and stream incisions (Trosper 2006 and Trosper et al. 2006).

The Structure Complex was first tested to explore site depth in 2005. Looted areas of above ground structures were also profiled. In 2007 test units were placed within the pilot GPR survey area, as well in other cultivated areas of the site. These units (1x1 and 1x2 meter) recovered some artifacts to a depth of 50 to 80 centimeters. The majority of these hand excavated units seldom extended below one meter depth.

In 2007, as hand excavated units were being completed within the rectangle of GPR coverage, probing with a metal rod revealed a shallow concentration of stone. This feature was first labeled the Central Buried Rock Feature or the Central Rock Feature. The feature is now known as the Central Structure. When the West edge of this stone feature was trenched by hand, sediments and tephra were discovered to a depth of 2.5 to 3 meters (Figure 10). The stratigraphy of this trench was then recorded and the strata were sampled. Charcoal samples were recovered and the first radiocarbon date for the strata above structure boulders was obtained (6190 +/- 40 B.P.). No artifacts were observed over the structure.

In 2009 this feature was tested with four backhoe trenches. Stratigraphic profiles and plan maps were made for all four trenches. Charcoal samples were recovered for the West and South Trench. Fragments of ceramics and one fragment of an obsidian blade were recovered from the 85 centimeters in the south wall of the West Trench. Test trenches were excavated by hand over Structures 1, 5, and 6. The backhoe was used to extend the hand trenching at the base of Structure 1 revealing two more stone walls used to form wide terraces on the southern portion of Structure 1 and yielding a charcoal sample for radiocarbon dating.



**Figure 7. Excavation profiles from Structure Complex during 2005 to 2006 (Trosper 2006).**

The Rockshelter strata (Figure 8) correspond well with those found in the trenches over the Central Structure (Figure 10 and Figure 11), as well as Structures 1 and 5. A black coarse tephra found underlying the Rockshelter burial can be assigned an age estimate of between 6500 and 8500 Cal B.P. Based on stratigraphic position and age this unmixed tephra most likely correlates with both the lower consolidated and unconsolidated (weathered gray) tephra covering the Central Structure (Figure 10). Similar strata and tephra are recorded and dated for Structure 1 (Figure 12 and Figure 13), and for Structure 5 (Figure 14 and Figure 15).

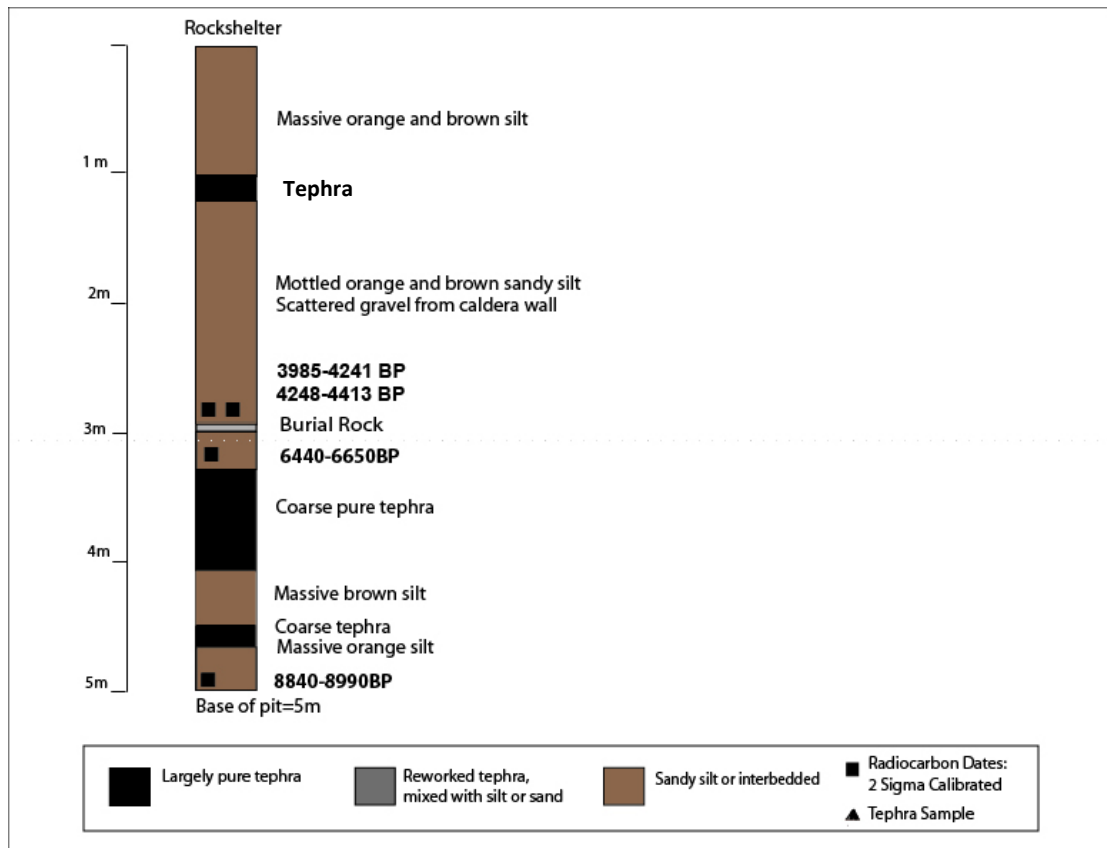


Figure 8 Stratigraphic profile from La Alberca Caldera Rockshelter (Trosper 2006).

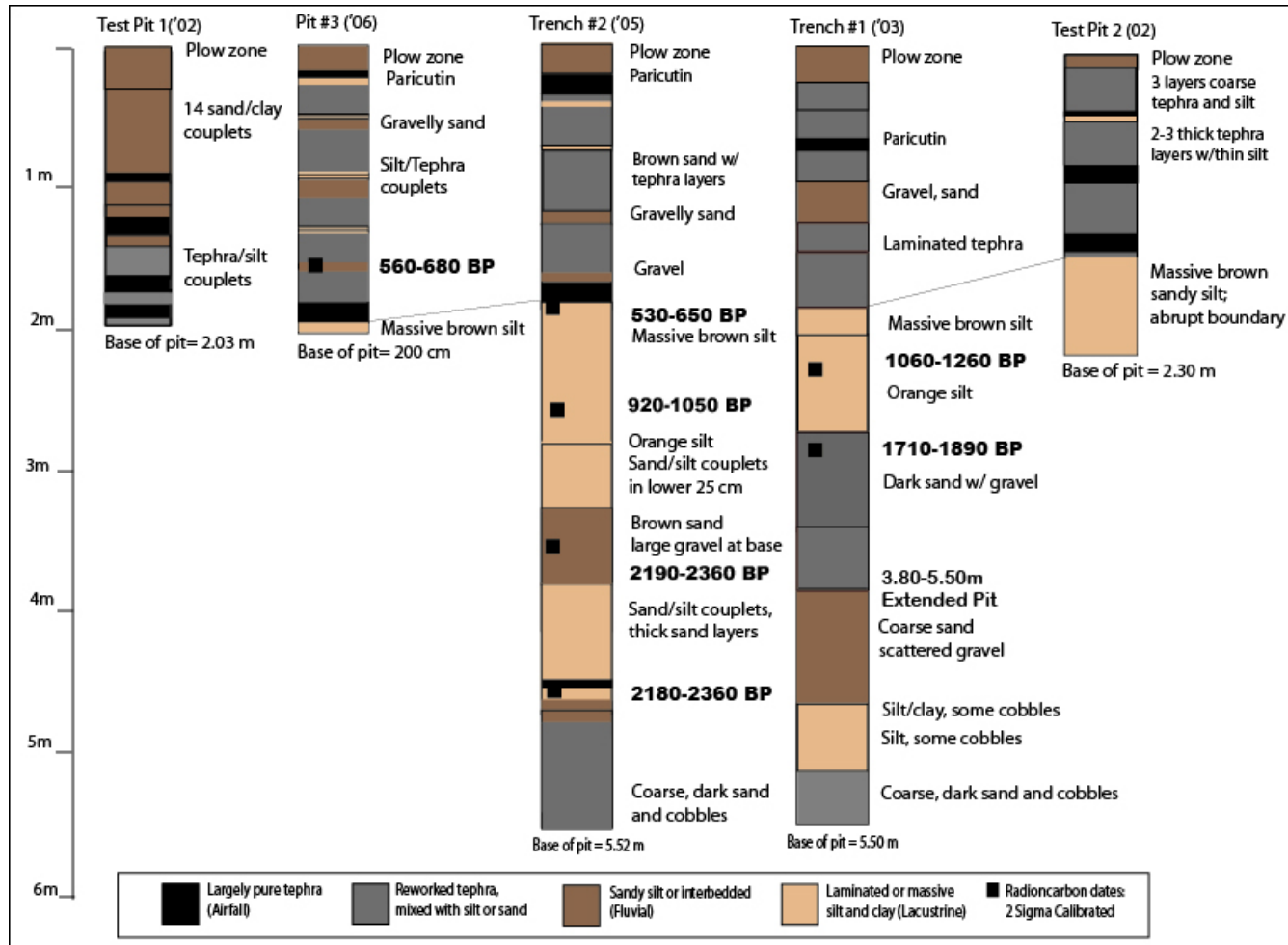
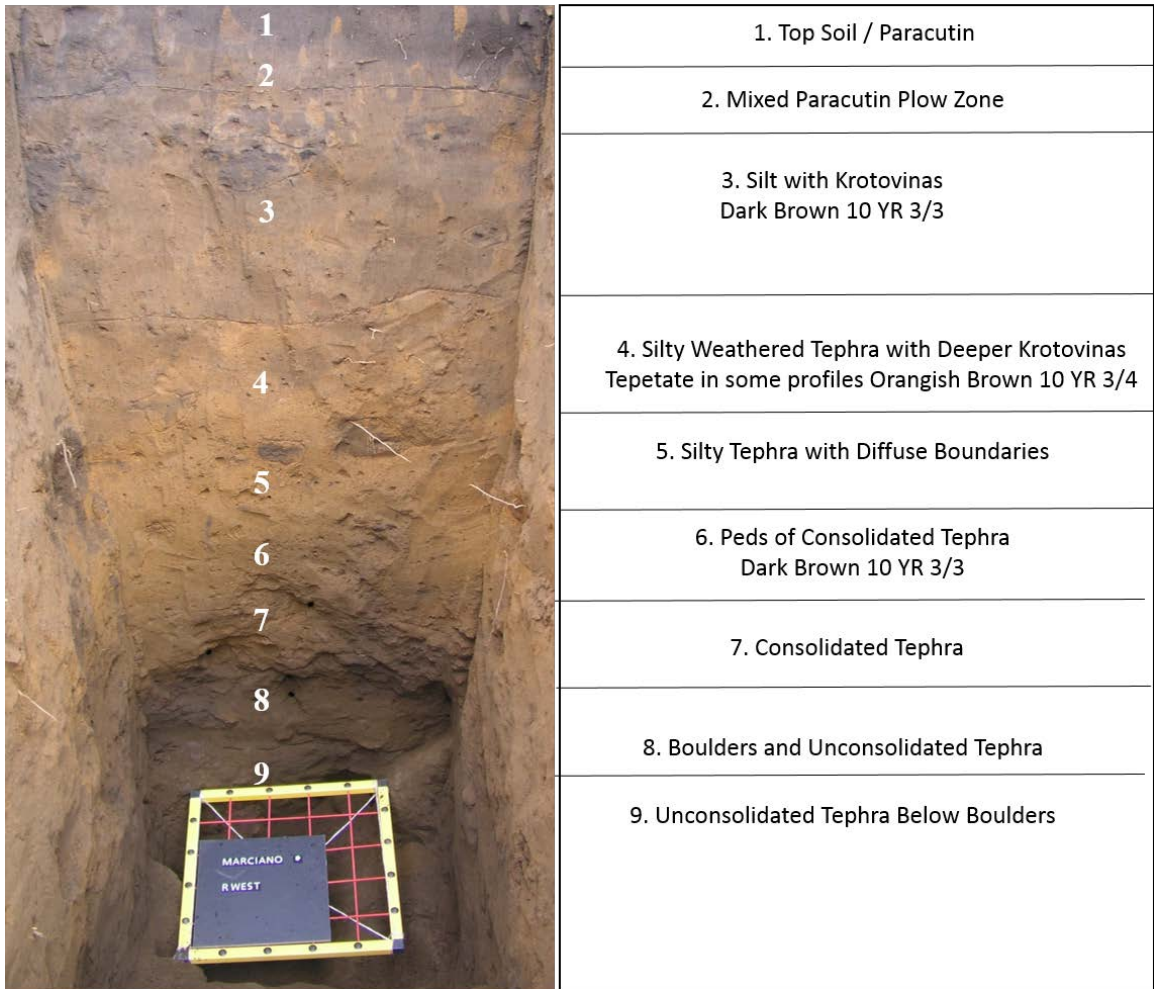


Figure 9. Stratigraphic profiles of the Caldera's floor trenches.





**Figure 10. Profile Sequence from the Central Structure.**



**Figure 11. West trench of Central Structure north wall, Marc Fairbanks on bolder surface.**

Figure 10 shows a 2.5 meter deep profile for the West Wall of the trench excavated over the Central Structure. The top two strata (Stratum 1 and Stratum 2) in the sequence include Paricutin ash and an upper plow zone. The plow zone overlays the brown silt of a buried soil (Stratum 3). This soil is heavily mixed by both earlier plowing and rodent activity as seen by the presence of *krotovina*. Stratum 4 includes pockets of consolidated gray tephra. Elsewhere in the site this consolidated gray tephra can be found in a 3 to 4 cm thick layer. Soil horizons such as this are referred to as a *tepetate*; which is a term coined by the Aztecs describing soils that are hardened by compaction or cementation, they are primarily found within volcanic regions (Williams 1972). The oldest observed ceramics from the site have been recovered just above and below this stratum at about 80 centimeters. This tephra most likely correlates to the one meter deep tephra in the Rockshelter and the five meter deep tephra on the Caldera floor (pre 2300 B.P.; calibrated 2180-2240 B.P. Trosper 2006).

The lower orange silty Stratum 5 is marked by diffuse boundaries. Stratum 6 and Stratum 7 are comprised of compacted or concreted tephra, Stratum 6 is more oxidized and thus orange. Stratum 8 includes unconsolidated gray-brown tephra and the bottom tier of stones in the Central Structure. The stone appears to be laid into, or on, the tephra and thus Stratum 9 is represented by the unconsolidated tephra that appears below the lowest tier of stone.

Deeper backhoe trenching also targeted two areas within the area of our pilot GPR project. Within the GPR survey area, near the *Cejocope* tree, stacked boulders were found in the northwest corner of a 5x5 meter excavation. Three tiers of large

boulders (two to four meters deep) extended three meters into the excavation. A single large boulder was uncovered at the depth of 1.5 meters in an adjacent backhoe excavation. The strata in both of these excavations correlate with strata observed in profiles for other structures, although the lower tephra in the 5x5 meter excavation extend to four meters in depth.



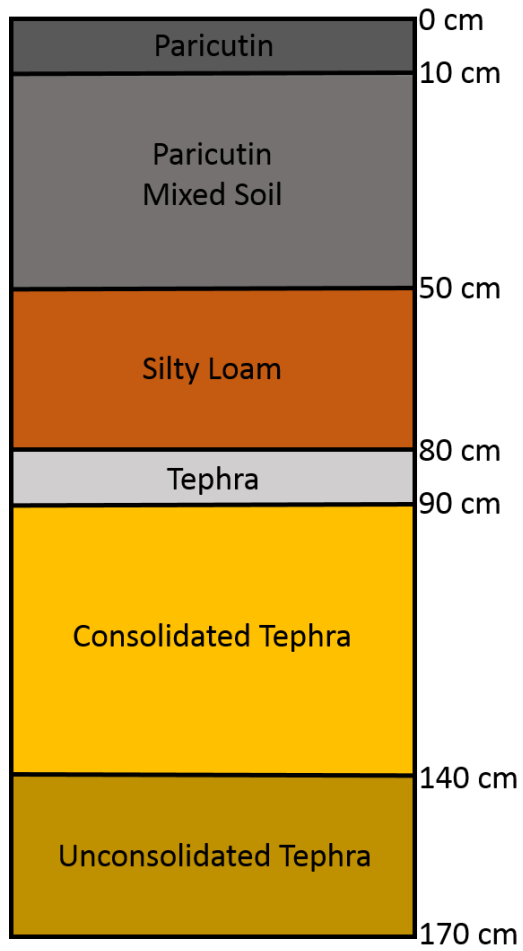


Figure 12. Stratigraphic profile of Structure 1.



Figure 13. Trench of Structure 1 showing exposed structure.

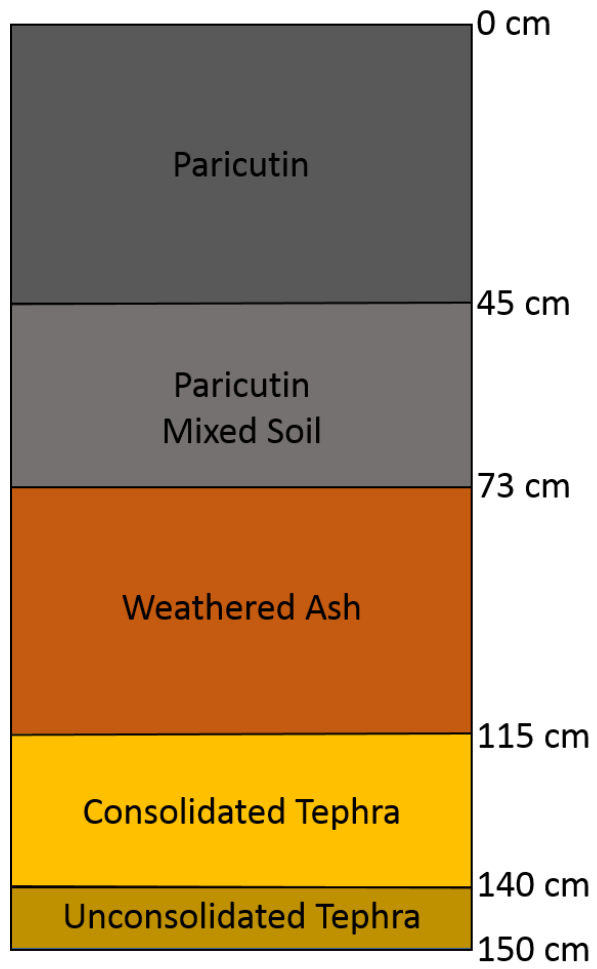


Figure 14. Stratigraphic profile of Structure 5.



Figure 15. Trenching Structure 5.

Sediment and tephra samples were collected to the north of the Structure Complex. A profile was cut on the slopes above the site on the main road (Figure 16). Two profiles were cut on the lower stream incision (Table 5 and Table 6) forming the northern boundary of the Structure Complex. The deepest black coarse tephra in the road cut and stream incision are undated (Figure 16). However, based on similarities in color and particle size it is most likely that these tephra correlates with the lowest tephra from within the Rockshelter. The buried tephra of the Rockshelter and the Road Cut are less weathered and oxidized than the tephra from the stream incision and the profiles over features on the Structure Complex.

The deepest Road Cut tephra is similar in composition to the lowest recovered black tephra of the Caldera (Figure 9; pre 2300 B.P.; calibrated 2180-2240 B.P.) (Newton 2006). Both samples are similar in geochemical composition to the deepest black tephra from the Rockshelter ((Cal 8440-8880 B.P.) (Newton 2006). All of the samples show compositions in the range of Basaltic Andesite and Andesite typical for monogenetic cinder cones (Newton et al. 2005, Newton 2006). A working hypothesis is that tephra from different periods of eruptions of the same or nearby cones will share overall similar mineral composition. Although the origins of these tephra are unknown they might be sourced to Jorullo (Newton 2006). A full tephrochronology has yet to be constructed for Jorullo or other local cones.









**Figure 16. Roadcut showing tephra deposition.**








## Magnetic Susceptibility

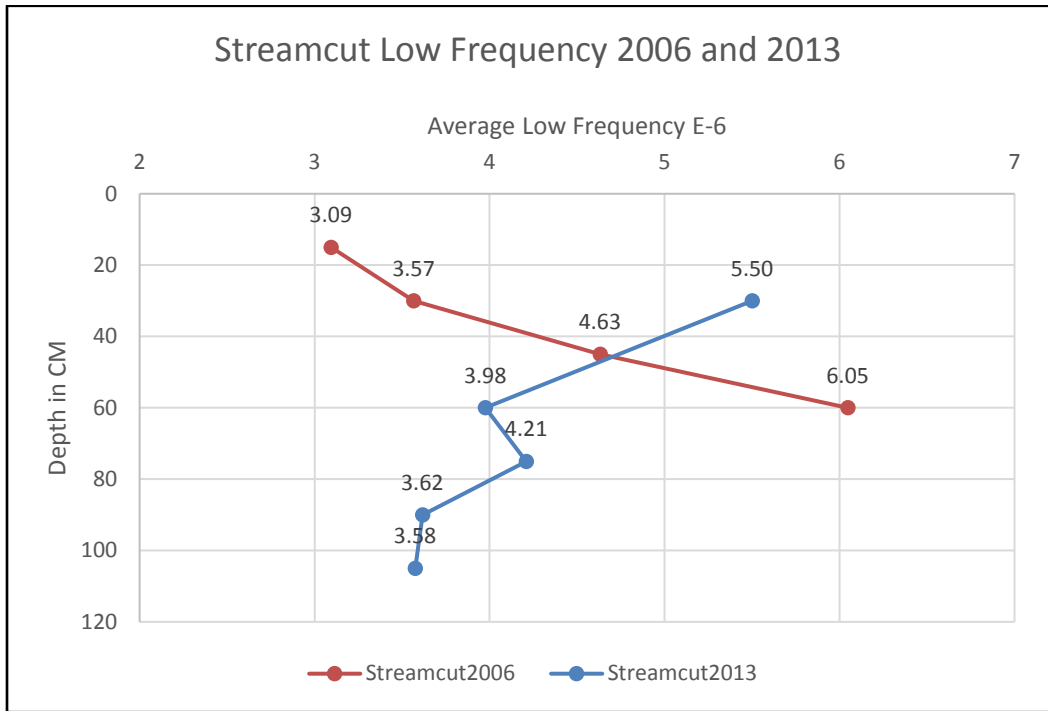
The magnetic susceptibility (MS) of the two sets of Stream Incision samples (2006 and 2013) are graphed in Figure 17 and Figure 18. These graphs were created in Microsoft Excel from the results of a Bartington MS Instrument and the Bartsoft data program. Figure 17 shows low frequency MS readings and Figure 18 shows frequency dependent MS readings. All of the MS readings are high due to the iron content (50-60%) of the andesite tephra. The low frequency values for the 2006 and 2013 samples do not follow a similar trend (Figure 17). However, similar trends are found in the frequency dependent readings (Figure 18). The rise in values between 80 and 40 centimeters probably reflects slower deposition rates and more in place weathering of strata. Although these first results are inconclusive future applications of MS will help further characterize the deposition of tephra and the formation of soils of weathered tephra.

**Table 5. Descriptions of tephra samples taken from Streamcut (adapted from Hackenberger 2005-2013).**

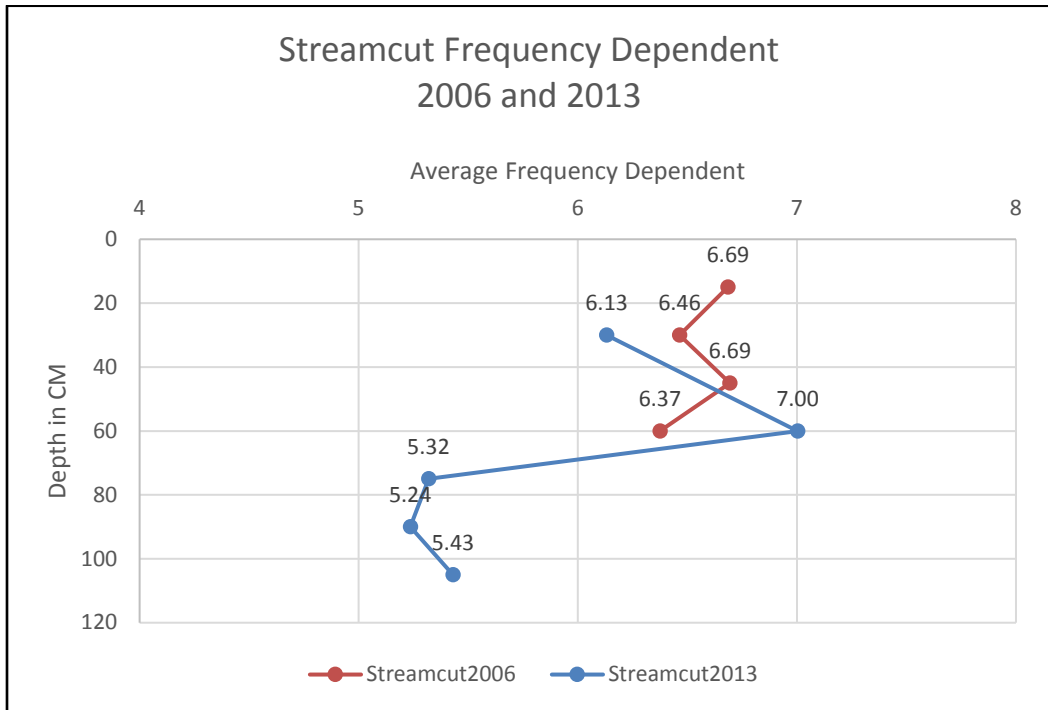
<b>Depth (cm)</b>	<b>Stratigraphy Observations (Grain Size, Color and Additional Observations)</b>	<b>Photo</b>
0-33	Sandy-silt size. Dark brown, bioturbated sediments with tephra filled burrows.	
33-120	Medium to fine sand size. Color varies from dark brown to orange brown. Sediments are bioturbated and burrows are filled with tephra.	
120-170	Sand size. Black and orange tephra nodules. This unit is very compact and hard, the mineral grains are oxidized and appear in multiple colors (green, red clear).	
270-285	Sand size. Black with yellow minerals. Very compact mostly pure tephra.	

**Table 6. 2013 Streamcut Sample munsell color classification.**

<b>Depth (cm)</b>	<b>Munsell Color</b>	<b>Photo</b>
30	10YR5/4	
60	Mixed 2.5YR4/4 and 2.5YR3/1	
75	10YR4/3	
90	5YR4/2	
110	Mixed 2.5YR4/2 and 2.5YR4/1	



**Figure 17. Low frequency magnetic susceptibility results for the streamcut.**



**Figure 18. Average frequency magnetic susceptibility results for the streamcut.**

## Ground Penetrating Radar

In May of 2007 Dr. Lanbo Lui (UCONN) conducted a pilot Ground Penetrating Radar (GPR) survey using a GSSI SIR 3000 control unit and a shielded 200-MHz model 5106 antenna unit (see Figure 19). The survey covered a 41x96 meter grid area (see Figure 20) survey (Liu et al. 2008). An inline spacing of five to six centimeters was generated for 42 lines each 96 meters long.

The rectangular grid was on a level plane south of Structure 1 and included a single *Cejocope* tree which continued to serve as a landmark for position test units and backhoe trenches. The maximum penetration depth for the GPR was generally greater than three meters. Lui (2008) presents an analysis of the GPR data and illustrates potential ancient horizons which match strata revealed in subsequent excavations (see Figure 21 and Figure 22).

In most of the test units excavated within or near the GPR survey grid contained a stratum of consolidated gray tephra that was identified in the GPR profiles as Horizon 1 (Liu et al. 2008). Hand excavations conducted in the summer of 2007, before the 2008 publication of results, could not reach Horizon 2. Horizon 2 was estimated to vary from two to two and one-half meters in depth. An example of one deeper anomaly is seen in the time profile (Figure 21). Larger patterns of anomalies (estimated to be 60-80 cm in depth) are seen in the time slices in Figure 23. These patterns form interesting configurations. The patterns may represent lower areas with concentrations of consolidated tephra such as trails or patios, or the surfaces of deeper boulder structures and walls.





Figure 19. The GSSI SIR 3000 GPR system with the 200 MHz antenna unit at the site.

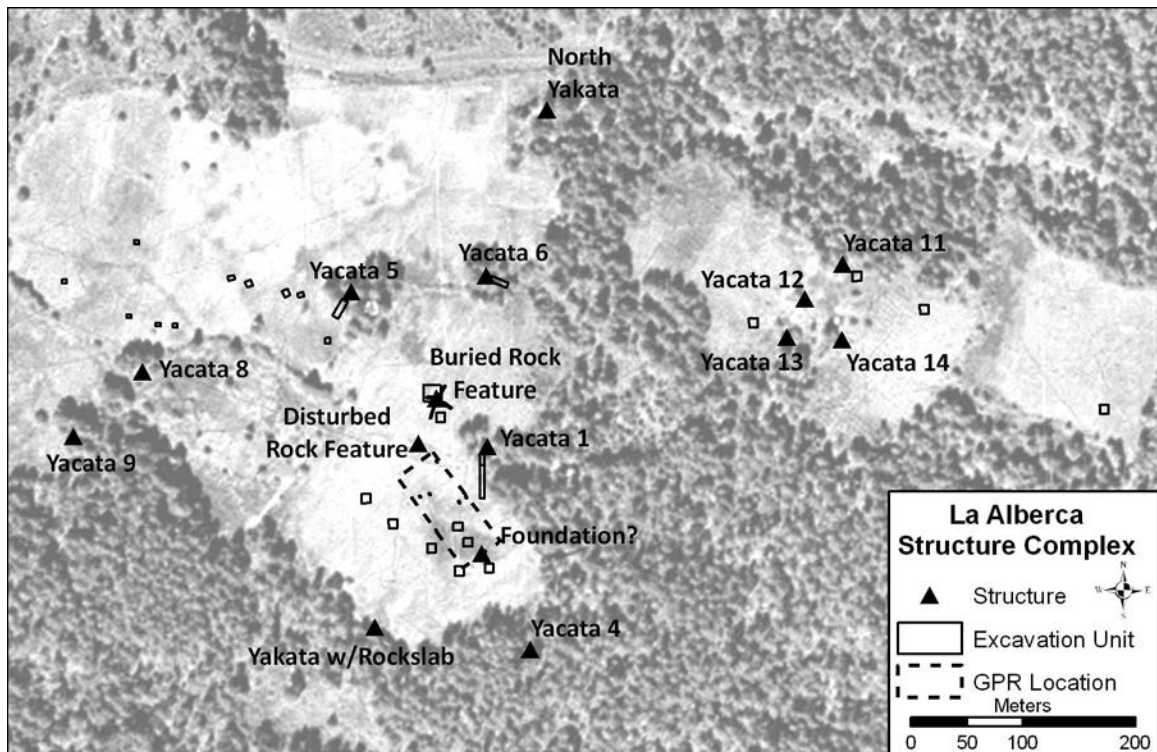


Figure 20. GPR grid within the Structure Complex. The Central Structure is labeled “Buried Rock Feature” (2007 Map courtesy of Marc Fairbanks).

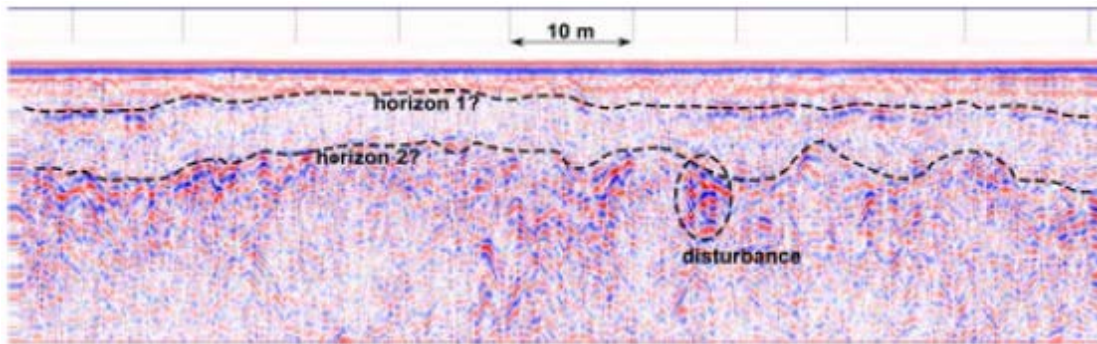
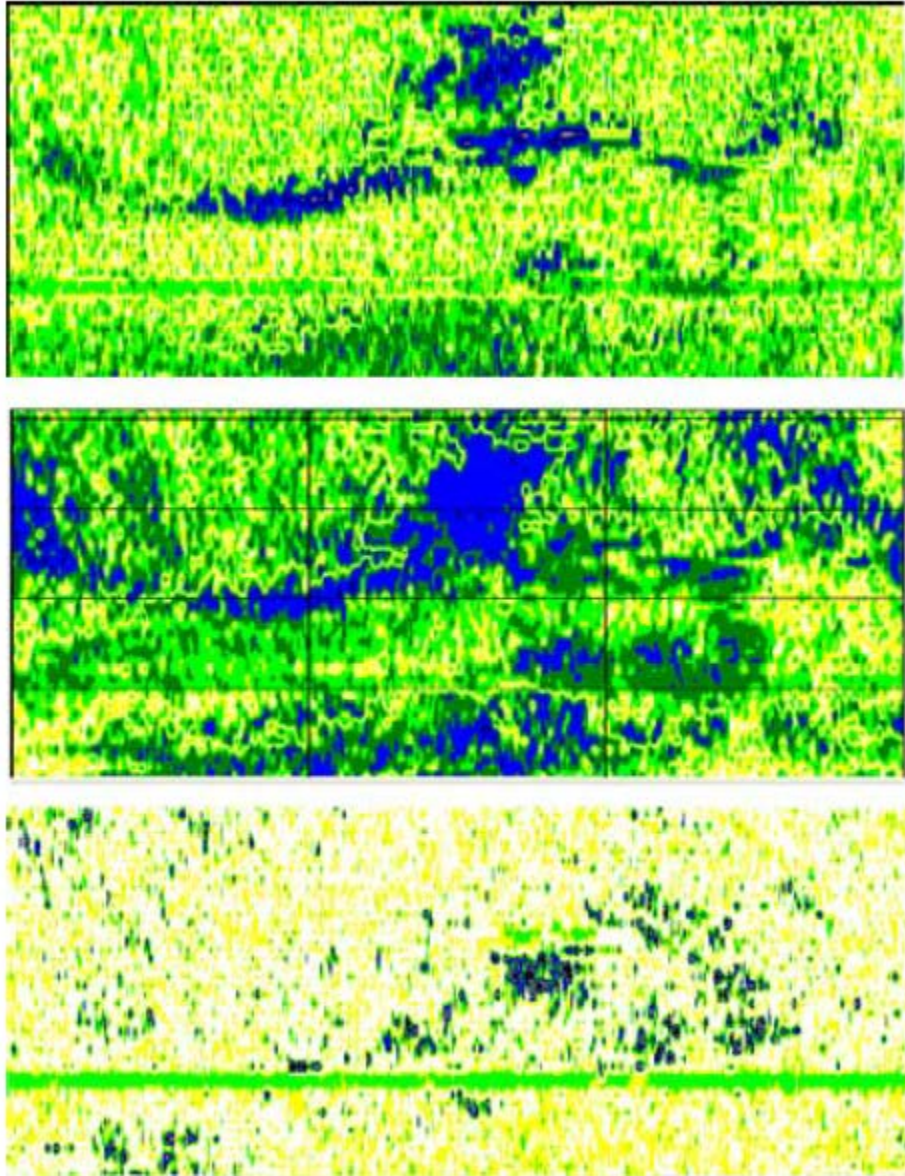


Figure 21. An example of a GPR profile showing potential ancient horizons (Horizon 1 6-80 cm) and Horizon 2 about two meters) The full depth, based on return time, is 3 meters (Liu et al. 2008).



Figure 22. A buried gray consolidated tephra (60-80 cm deep) shown in a 1x2 meter (Liu et al. 2008).





**Figure 23** Example of GPR time slice images top to bottom. A potential buried structure can be seen via color contrast within the image (Liu et al. 2008).



The 3-D cube in Figure 24 shows anomalies in red that appear at 1.5 meters deep. The two red patches are of special note. These two patches (left of center), are located to the right or east of the break in the survey line interrupted by the *Cejocope* tree. These two anomalies correspond with the size and shape of the boulder structure and the large boulder found in backhoe trenching east of the *Cejocope* tree.

In order to explore for deeper features, backhoe excavations in 2009 were conducted just east of the *Cejocope tree*. Here the tiered boulder feature was located. This features was buried two meters deep and extended to a depth of at least four meters. If symmetrical in form, the feature would be a circle or oval boulder structure at least 6 to 8 meters across. Further GPR work and future excavations are obviously needed to help better understand the full extent and complexity of the Structure Complex (Liu et al. 2008).

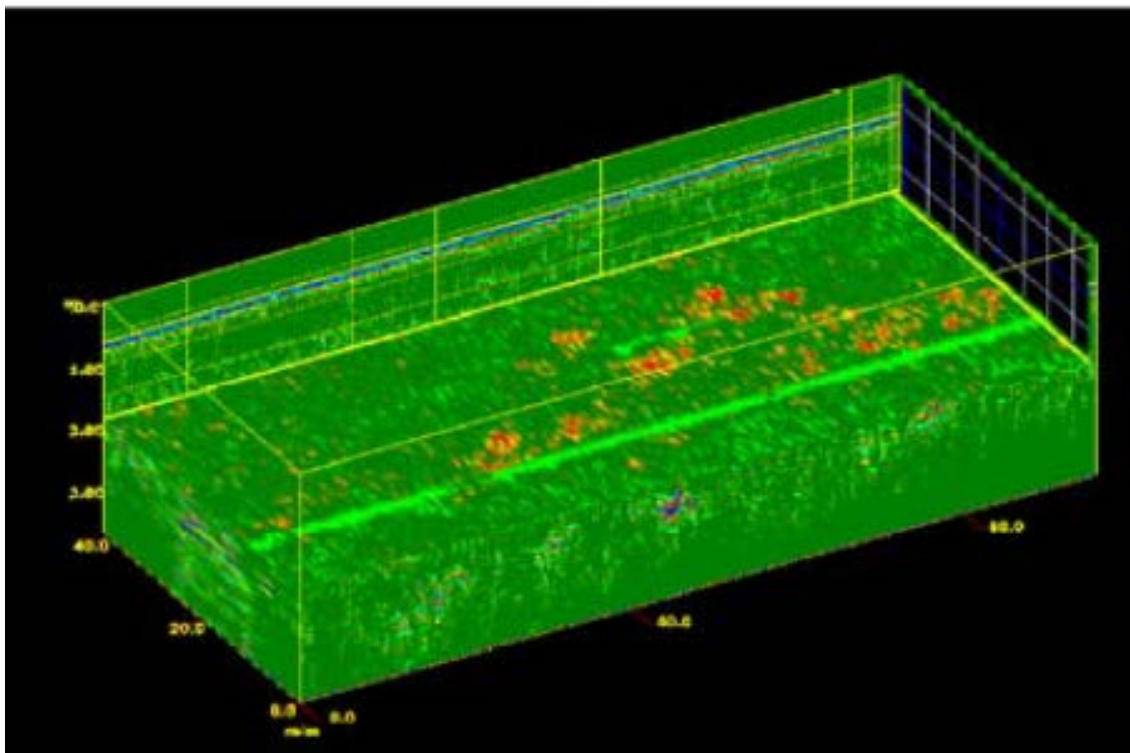


Figure 24. 3-D model of the GPR survey with a cut exposing subsurface anomalies at 1.5 meters below surface (Liu et al. 2008).

## CHAPTER IV.

### METHODS

This section covers field methods and techniques for computer spatial analysis and 3-D visualization. The consolidation and organization of all field materials has been an essential accomplishment of this thesis. Field materials include: field notes, photos, sketch maps, soil and tephra samples, radiocarbon ( $^{14}\text{C}$ ) dating results, ground penetrating radar data, and geographic information systems (GIS) data from the 2007, 2009, and 2013 field seasons. The acquisition of this documentation was fully accomplished. All of the field notes and sketches were scanned with copies going to both Dr. Hackenberger at Central Washington University and Dr. Gabany-Guerrero at the University of California-Fullerton. Tephra samples from a nearby stream cut were borrowed from Dr. Lisa Ely of the Department of Geological Sciences at Central Washington University.

#### Field Methods

The Central Stacked Rock Feature, the focus of this thesis, was first identified by the author during test excavations in 2007 (Figure 25, Figure 26, and Figure 27). Not much was known about the feature at this time other than excavations found it to be deeply buried, over 2.5 meters below surface.



**Figure 25. Photos of test excavation of the “Central Stacked Rock Feature” in 2007. Left: looking west down tier. Right: looking east up tier, note unconsolidated tephra under exposed rock and over buried rock.**





Figure 26. Photo of test excavation of the Central Stacked Rock Feature in 2007.

When the Structure Complex was revisited in 2009, extensive mapping was our priority (Figure 27 and Figure 28). Surface features were mapped with a total station and GPS units. Test trenches were placed over three of the structures (Central Structure, Yacata 1, and Yacata 5). The Central Structure was trenched with a small backhoe (Figure 29). Four trenches (the North, South, East, and West Trenches) were placed over the Central Stacked Rock Feature in the hopes of determining the overall shape of the structure (Figure 30, Figure 31, and Figure 32). Profile walls were sketched in the field and samples of soils, tephra, and carbon were identified and collected (Figure 12 and Figure 14).

### Radiocarbon Dating

Dozens of charcoal samples were collected from La Alberca Structure Complex and La Alberca Caldera Rockshelter for radiocarbon dating. Each sample was carefully documented with location and depth information, stratigraphic position, and had corresponding profile drawings and photos. They were removed with metal trowels and wrapped in aluminum foil, with as little handling as possible in order to prevent contamination. Seven samples from La Alberca Structure Complex (including MAR-RMWP1-2M) were sent to Beta Analytic Incorporated. The lab provided a final report package which outlined procedures, pretreatment methods, and calendar calibration information (see Appendix) (Hood 2009). Of special note sample MAR-RMWP1-2M was collected by the author in 2007 and it was this sample that gave the first indication of the possible early age of the Central Structure.

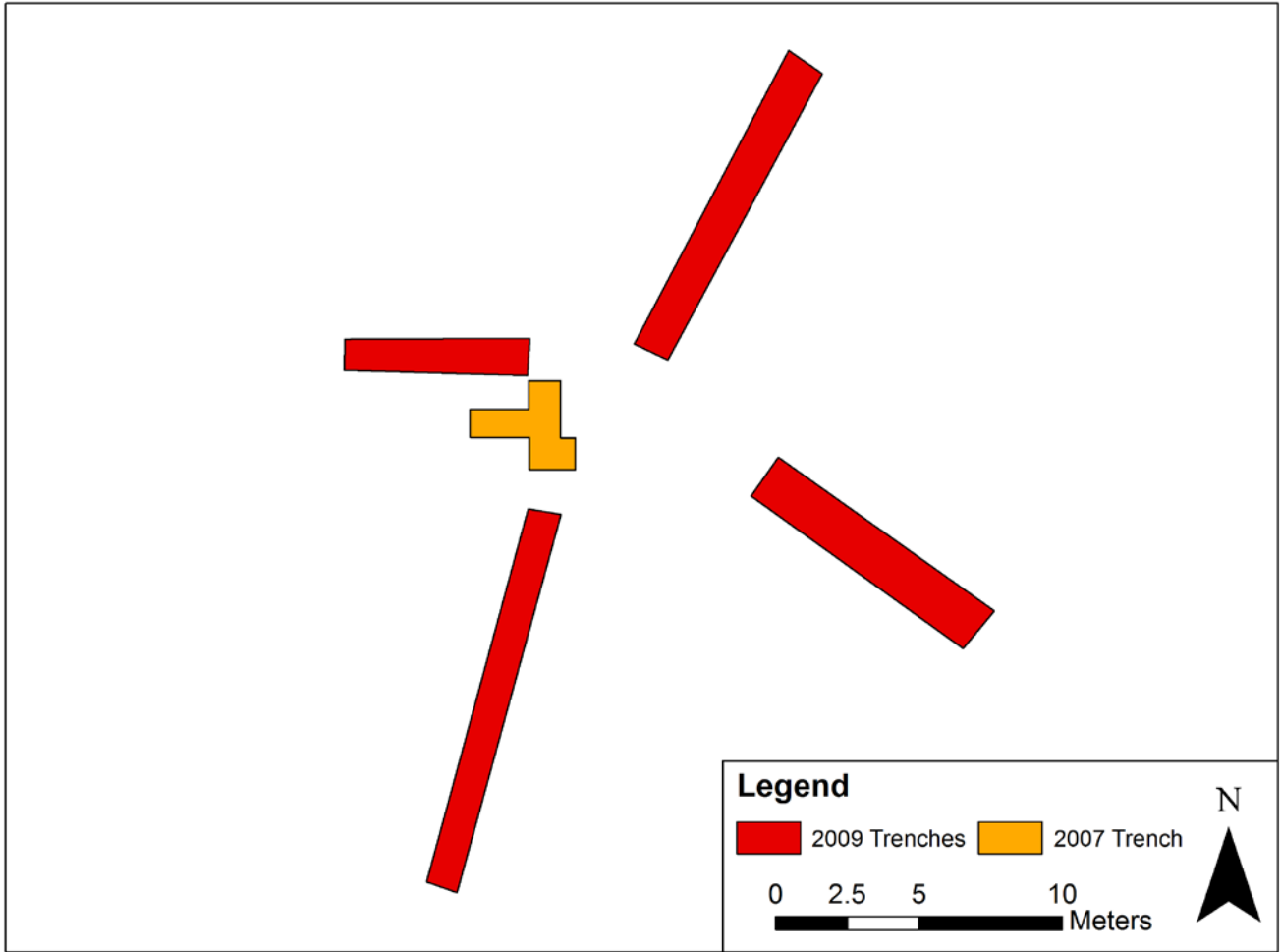


Figure 27. Map showing the configuration of trenches (in orange and red) excavated in 2007 and 2009 (adapted from DeLeon et al. 2013).

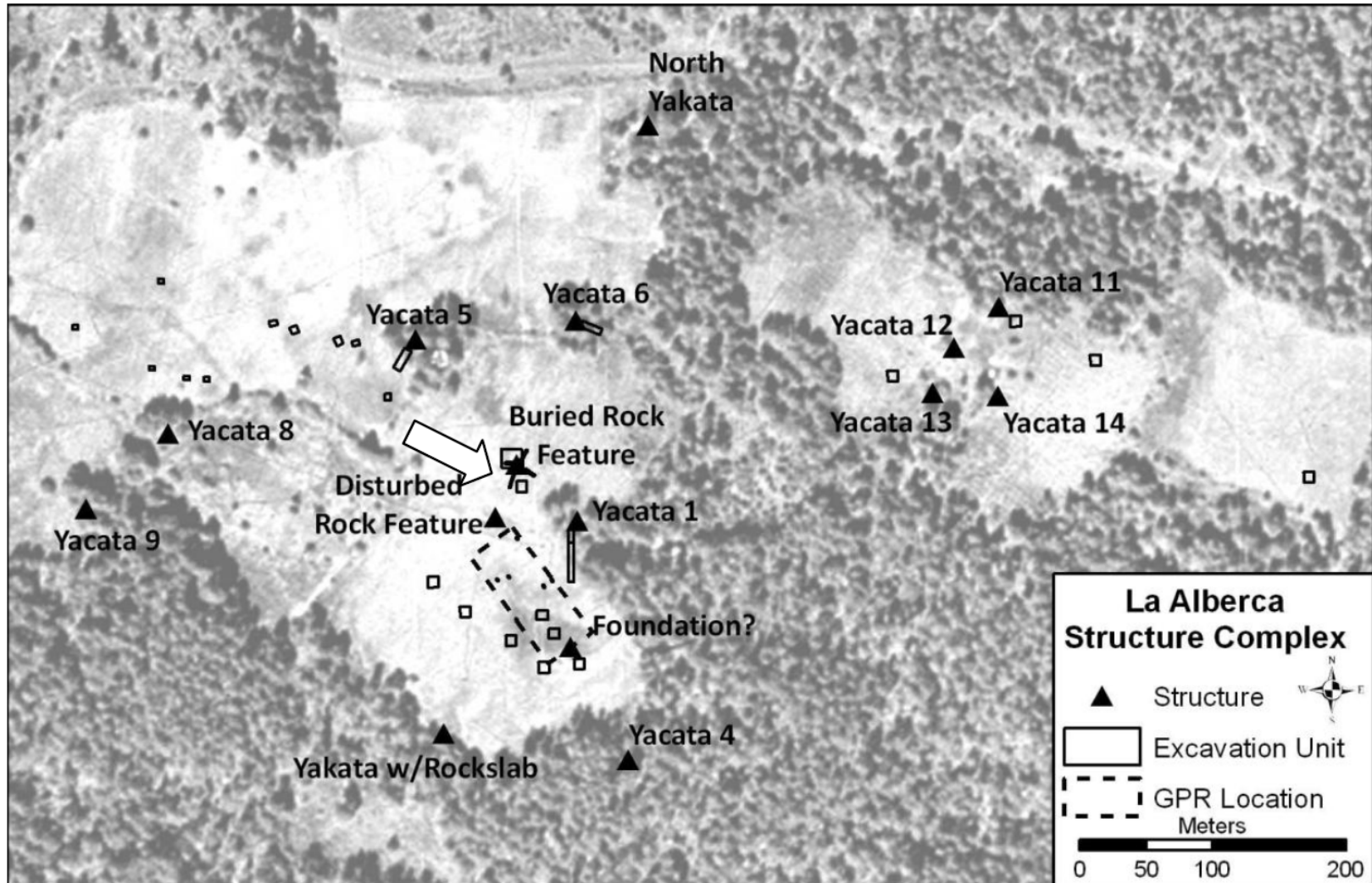


Figure 28. Map of La Alberca Structure Complex with the location of Buried Rock Feature (an early name for the Central Structure) indicated with arrow (Hackenberger and Gabany-Guerrero 2010: Figure 6).





**Figure 29. Photo of backhoe excavations.**



**Figure 31. Overview of East Trench, facing east.**



**Figure 30. Overview of North Trench, facing south.**



**Figure 32. Overview of South Trench, facing north.**

## Stratigraphic Profiling and Digital Spatial Modeling

Stratigraphic profiles were digitized from the scans of field notes taken from 2009 trenches excavated at Structure 1 and Structure 5. A profile description of the 2.5 meter deep 2007 trench was also created using field notes. These profiles are presented in the results section.

Digital models of sketch maps and profile walls from the four trenches excavated surrounding the Central Structure in 2007 were created from scanning field notes and digitizing them using computer freeware illustration software Gimp 2.8. A digital model of the Central Structure was also created using the same process but additionally incorporated GIS spatial data (Figure 33).

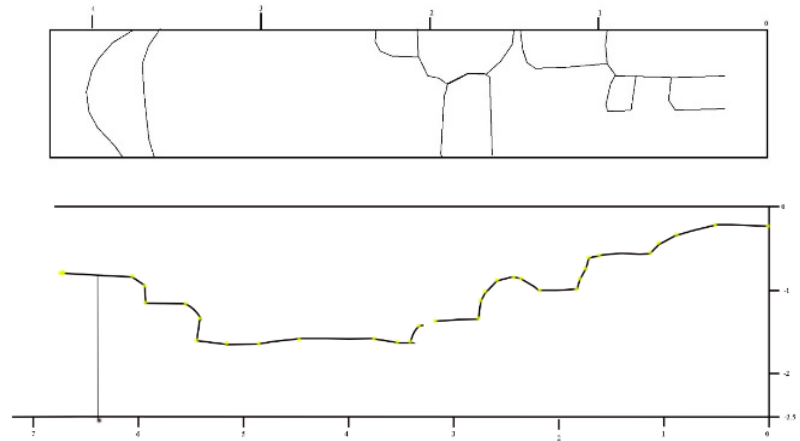
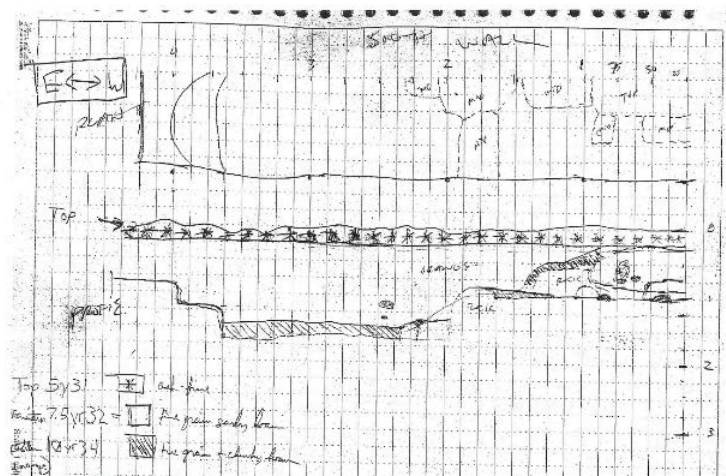
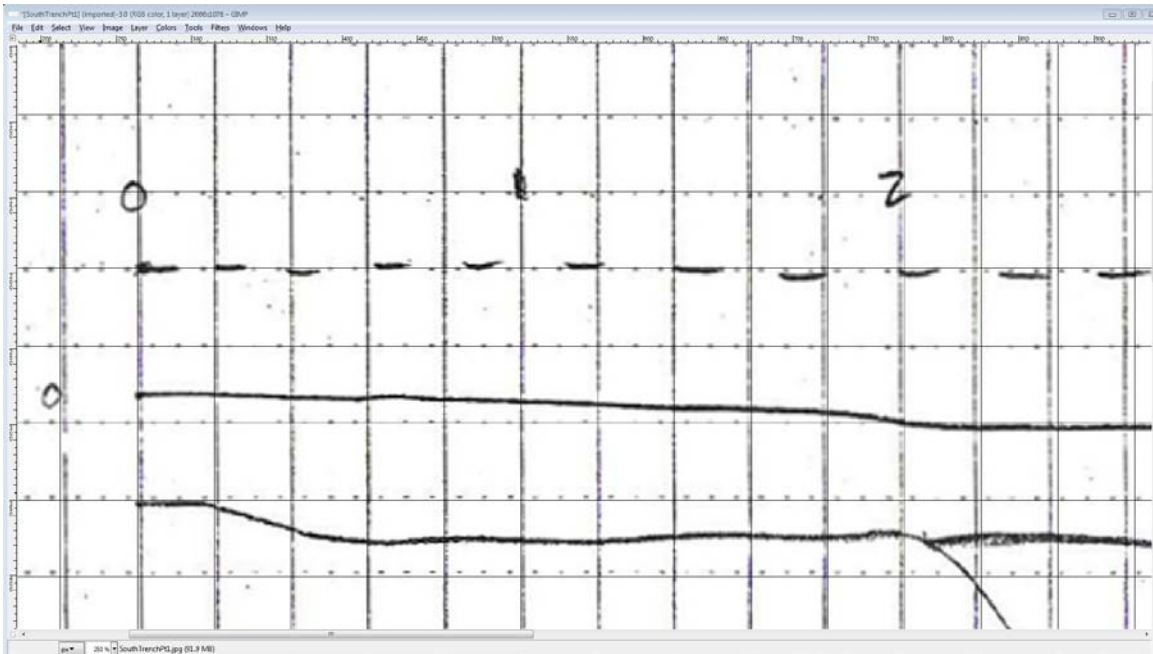


Figure 33. West Trench example profile.

### *Computer Digitization and Spatial Analysis*

All of the original, hand-mapped, profile drawings from the 2009 backhoe trench were scanned and electronically sent to Dr. Steven Hackenberger of Central Washington University. They were then digitized using the illustration software GIMP 2.8. The GIMP software proved to be an easy and accurate tool to standardize the scales of the four profile sketches when matching the original graph paper grid to the software's grid function (Figure 34).



**Figure 34. Example of matching the Scaling using GIMP 2.8.**

The scale and precision of the original graph paper grid proved to be inconsistent and not a “true grid” when applied to the GIMP grid function. To overcome this problem the two grids were aligned as accurately as possible to the original scale lines and then the profile drawings were cut and scaled to match the more accurate grid. The nature of the inaccurate graph paper grid may have resulted from the scanning process; it is

possible the page bindings lifted the pages causing them not to be flush with the scanner. Figure 34 shows the scale aligning nicely for the first two meters, but it starts to get off grid by the second meter line.

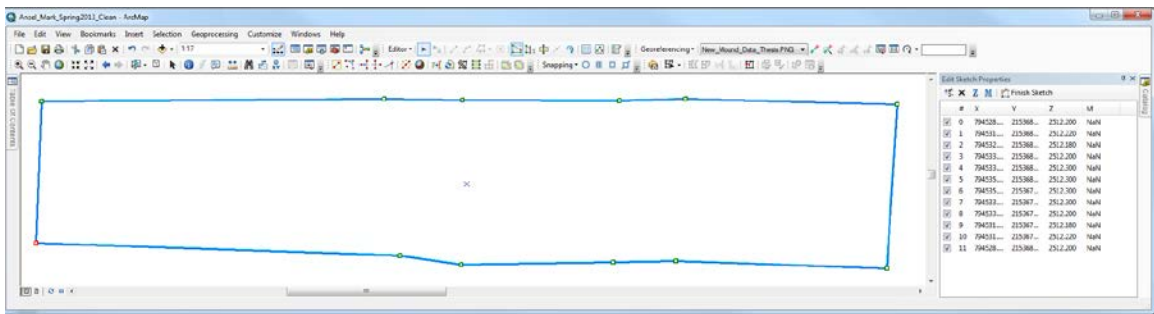
Once standardized, the scale was then used to calculate the elevation of profiled features within the sketch maps accounting for the three-dimensional Z-values of the features and the stratigraphy. The Z-values were calculated from the digitized profile drawings in arbitrary increments of 25 centimeters along the X-axis using the GIMP Software measuring tool. This measurement gave the total pixels below the datum where each feature or stratigraphic layer was located. An arbitrary zero, located at 2512.3 meters above ellipsoid, was assigned to each of the four trenches. This arbitrary elevation was based on the 2009 total station datum's elevation.

Using the acquired metric data from GIMP, the data was then run through an Excel formula of pixels from datum divided by the number of pixels in one meter according to the sketch map scale. The resulting number gave how many centimeters from datum the point of interest was. This data was then subtracted from 2512.3 meters to give the Z-value and was placed in a column alongside the corresponding X-value. The amount of data populated was extensive enough that transcription errors were a possibility so the Excel formulae were created to automate the process and reduce the possibility of human error.



## SPATIAL ANALYSIS OF TRENCHES: METHOD 1

Using the 2009 total station trench data, polygons were created in ArcMap 10.3 and then assigned vertices for the corresponding X and Y-locations. The Z-values were then mirrored with the X-values of the profile drawings to account for the 3-D Y-values of the trench. This created an acceptable but unavoidable dimensional bias, the width of the trench (Y-value), since two-dimensional data was being overlaid three-dimensionally. Each vertex coordinate was then overlaid on the X-Y footprint of the total station data using ArcMap sketch properties (Figure 35).



**Figure 35. Adding Z-values to the total station coordinates.**

This process created 13 new stratigraphic shapefiles for the four trenches excavated. Completed shapefiles were imported to ESRI ArcScene where they could be visually analyzed in 3-D. By doing this, outliers were immediately noticeable. In order to create a visual representation of the feature itself, the profile angles of the rocks had to be assigned similar XY-values using the same method repeatedly in order to create complex angles (Figure 36). The tops of the stratigraphic levels were relatively uniform but the complexity of the feature increased the vertices nearly tenfold.

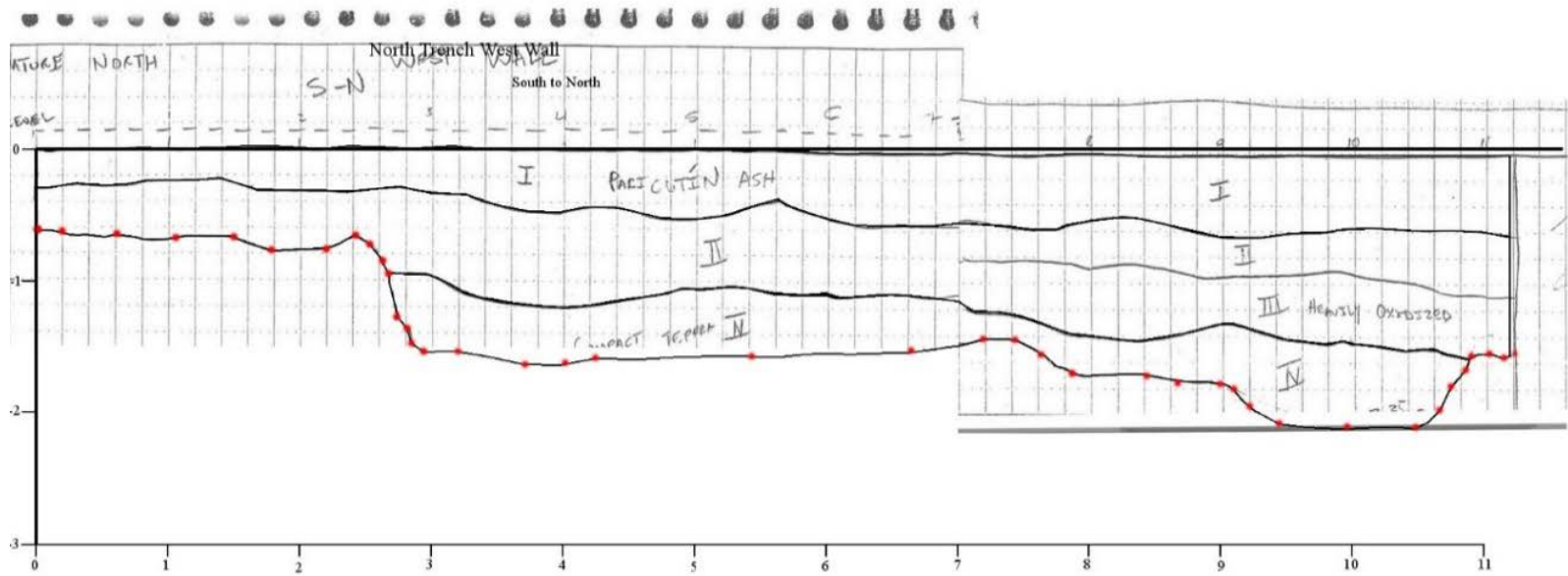


Figure 36. Image showing how depths were measured using GIMP 2.8. Red dots are depths used for mapping.

## SPATIAL ANALYSIS OF TRENCHES: METHOD 2

A second method was adopted in order to maximize visualization and proficiency. Plan views were rectified using the Georeference function in ArcMap. The four corners of the plan view were linked to the total station control points (Figure 37a). Attribute tables for each trench were given column titles that included trench, rock, Z, X, and Y (Figure 37b). Each rock was then assigned an arbitrary name attribute and Z-values were assigned to each rock (Figure 37c). A shapefile for each trench was created and every rock had multiple points (Figure 37d). Field calculator was then used to fill in Z-values for each assigned rock value. Afterwards, a Triangulated Irregular Network (TIN) was created from the 3-D analyst tools in ArcMap (Figure 37e). Following the creation of the TIN, render (modifying how the image is displayed) and symbology (unique values in which the image was created) were edited to maximize visualization (Figure 37f). This made data entry errors easily noticeable, and re-measurements and attribute corrections could be done.



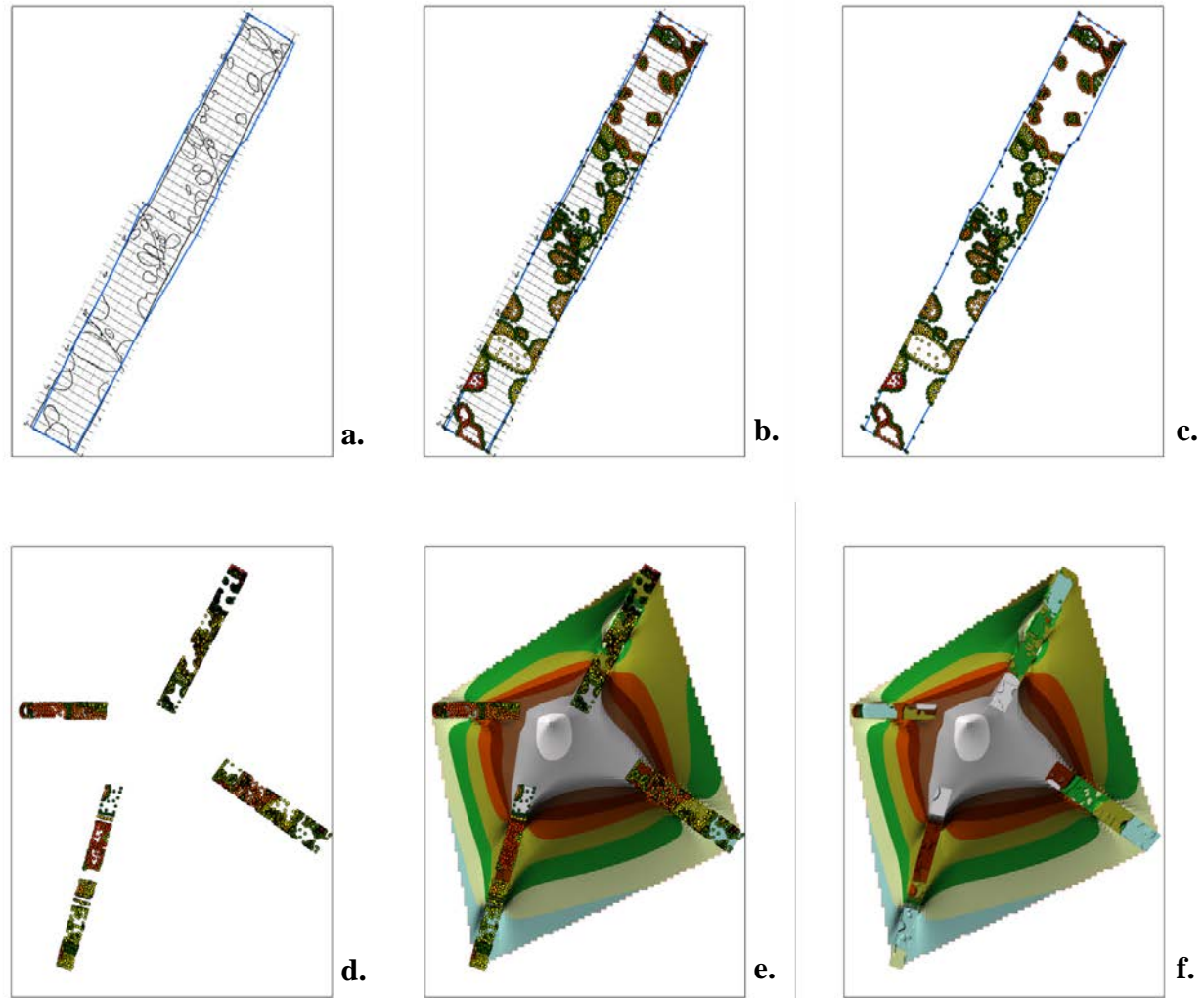


Figure 37. Step-by-step illustration of TIN creation process.

*Methods for the Spatial Analysis of 2013 Depth Data over the Central Structure*

In order to better understand the overall shape of the buried surface of the Central Structure, additional field data was collected in the summer of 2013 by the author, Dr. Steven Hackenberger, and Dr. Morris Ubelacker. Using the same datum that the 2009 total station used, a north-south grid was created with meter tapes. T-shaped, metal rods were used to systematically probe the surface depths of the feature (Figure 38). When the probe hit a rock or boulder the rod was grabbed at surface level and then pulled out revealing the depth below surface of this object. This depth was then measured and plotted on a graph. This data was then added to ArcMap and a TIN was created using the Z-values (Figure 39 and Figure 40).



**Figure 38. “T” shaped probe used to gather depth data in 2013. The probe was also used to test the bottom of trenches in 2009 as shown in photo.**

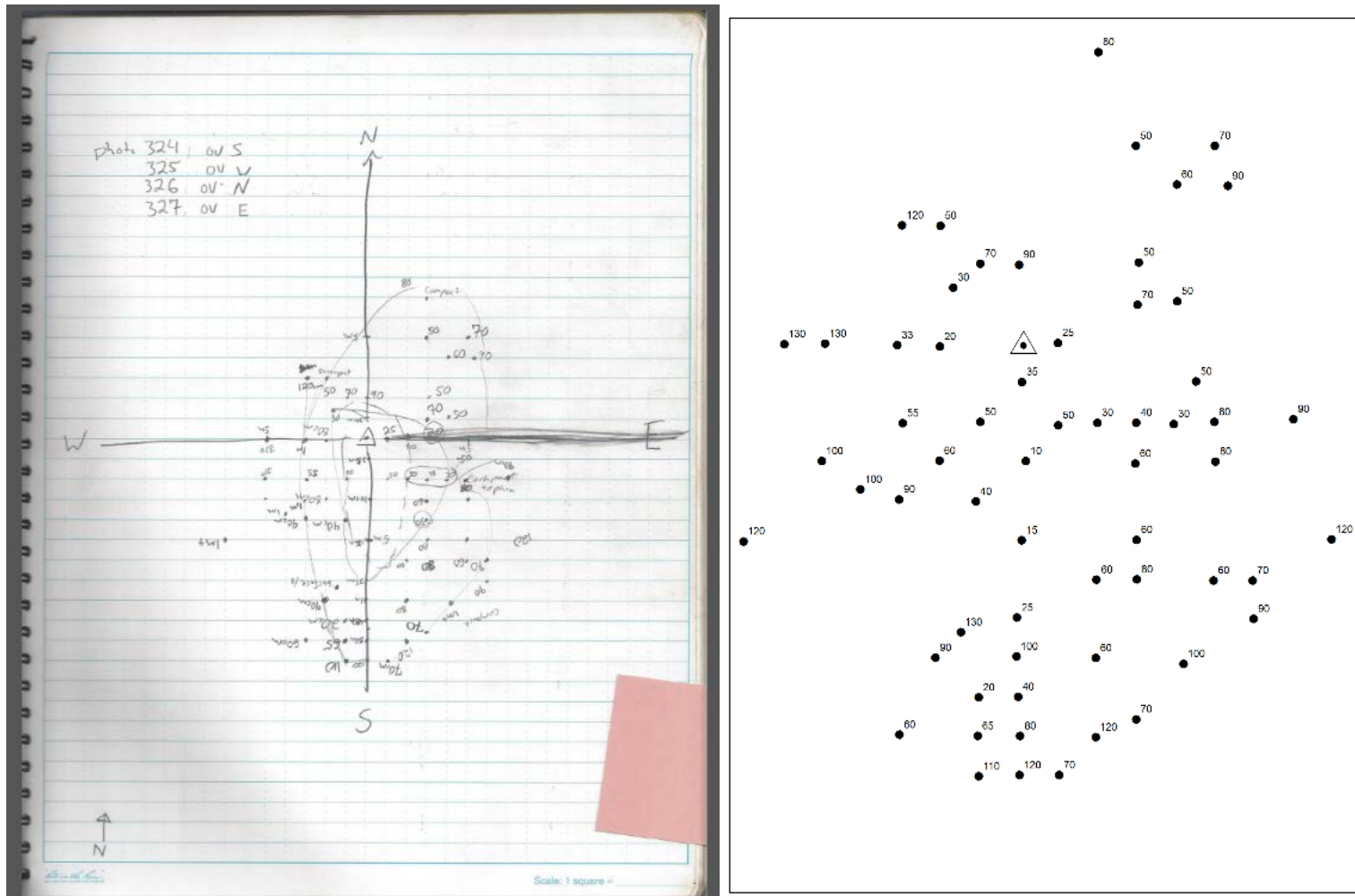
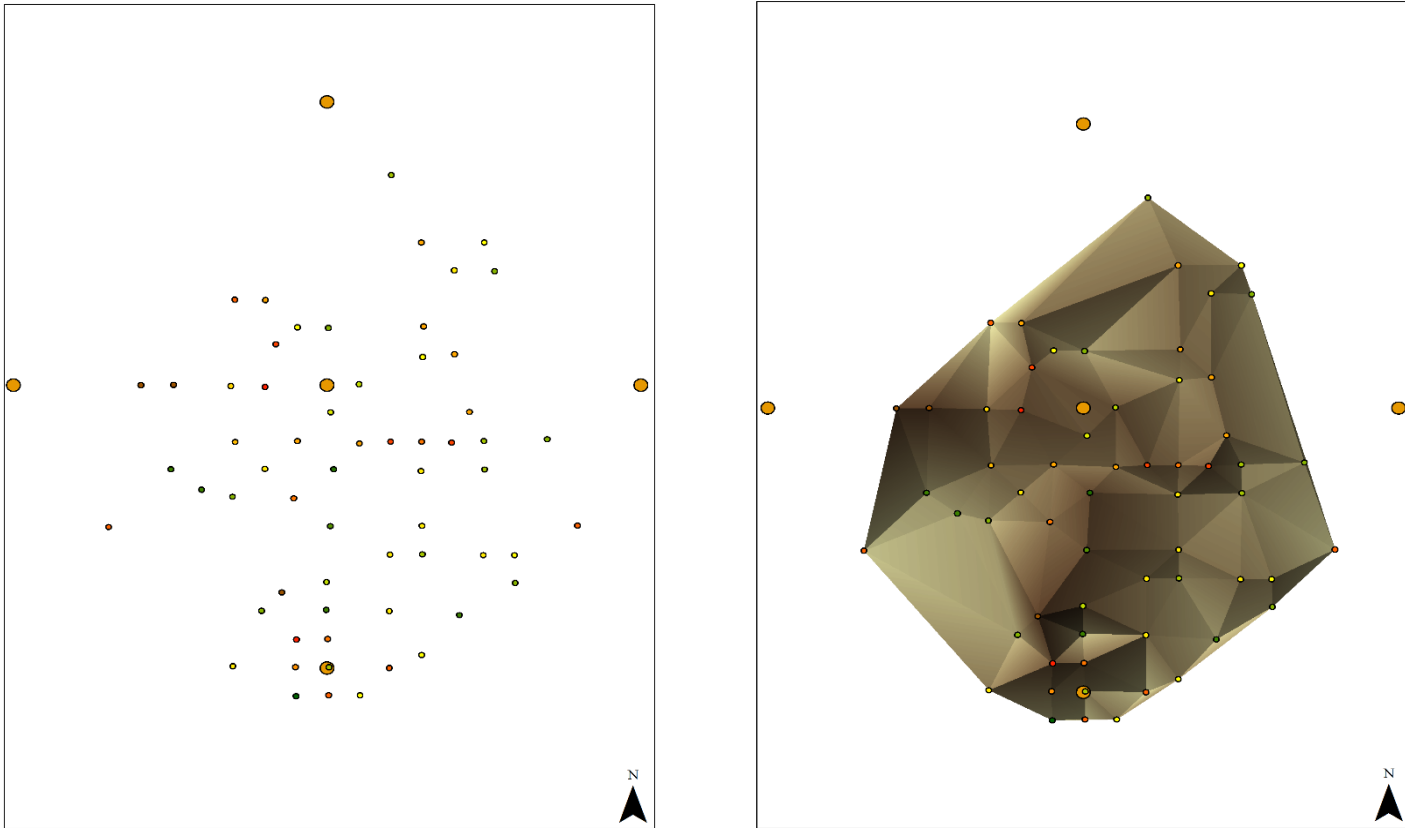


Figure 39. Digitization of 2013 raw depth data from field notebooks into ArcMap 10.3.



**Figure 40. 3-D modeling of digitized 2013 depth data. Image showing data points interpolated into a TIN representing the shape of the structure's top.**

## CHAPTER V.

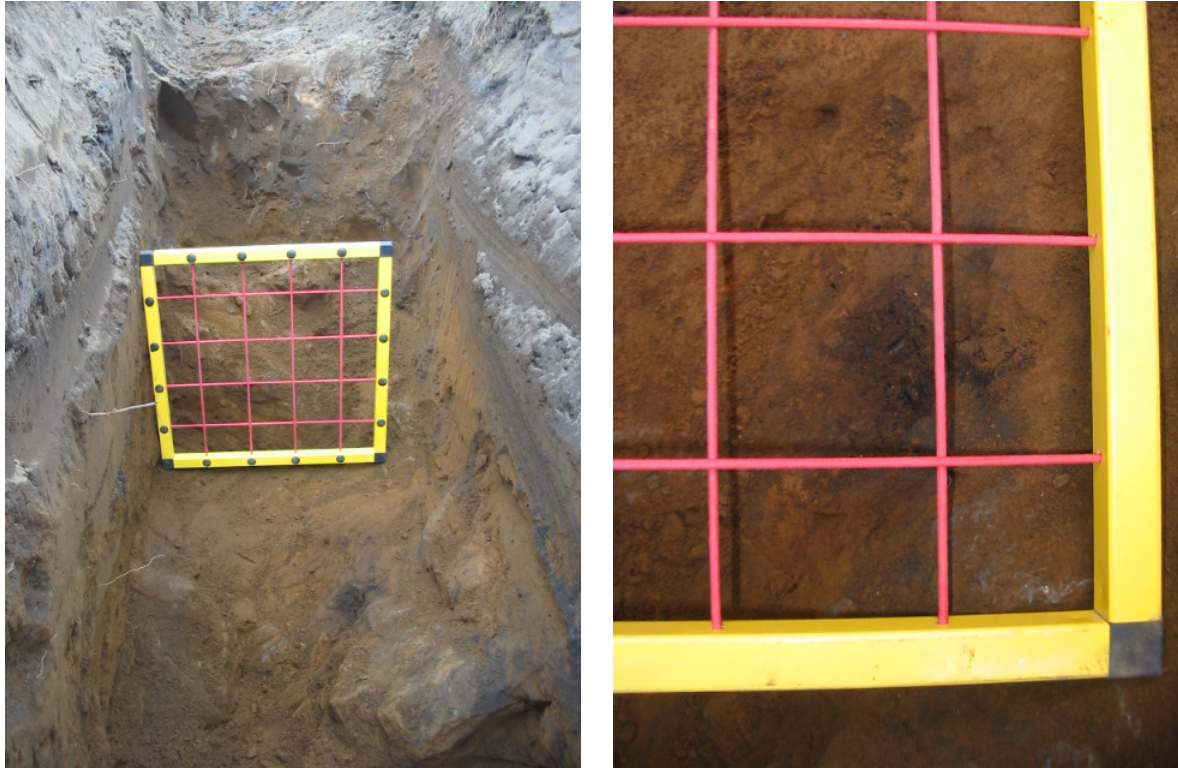
### RESULTS

This section gives an overview of the results of this research. The first section outlines the radiocarbon dates and interprets their significance in establishing the Late Archaic origins of the Central Structure and Structure 1. The second section summarizes the stratigraphic profiles that document the integrity of deposits overlying the buried structures. The superimposition of coarse tephra at the base of the structures is well documented. The third section summarizes spatial mapping results, and computer generated 3-D models.

#### Radio Carbon Dating

Radiocarbon dating of occupation surfaces and one structure were completed for the northeast sector of La Alberca Structure Complex (see Table 7). The Central Structure now has a total of four radiocarbon dates spanning a period of ca. 5700-6200 years ago (Hackenberger et al. 2010b).

The dated carbon samples were collected from the strata of silty weathered tephra found over the boulders of the Central Structure. The samples yield a well sequenced range of dates (7245-6470 cal B.P.) (Figure 41, Figure 43 Figure 42, and Table 8).



**Figure 41. Photograph of the carbon, sample. Top: sample lays on surface of second tier of stone. Bottom: close up of resinous charcoal sampled.**



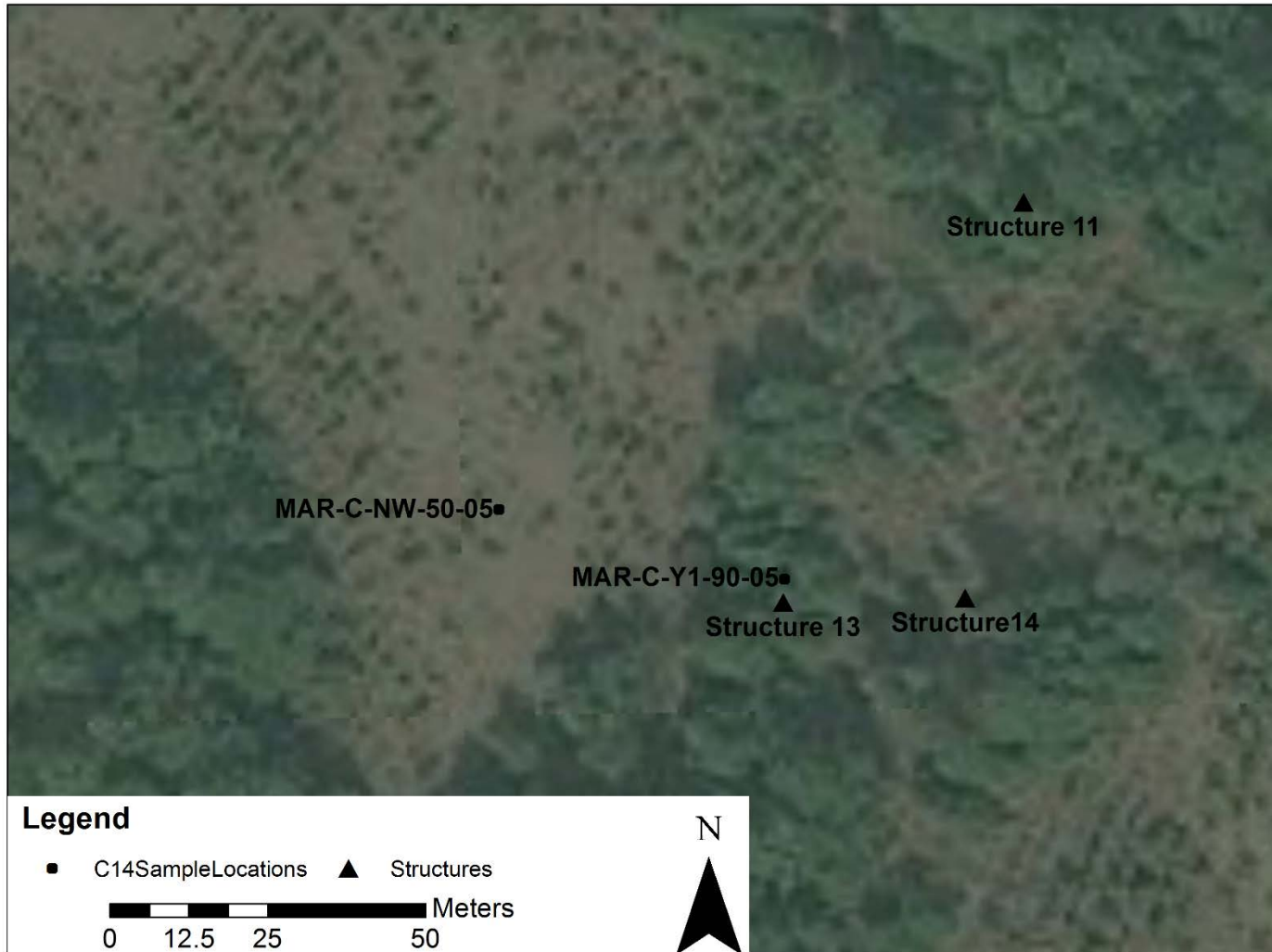


Figure 42. Location of carbon samples northeast sector of site.

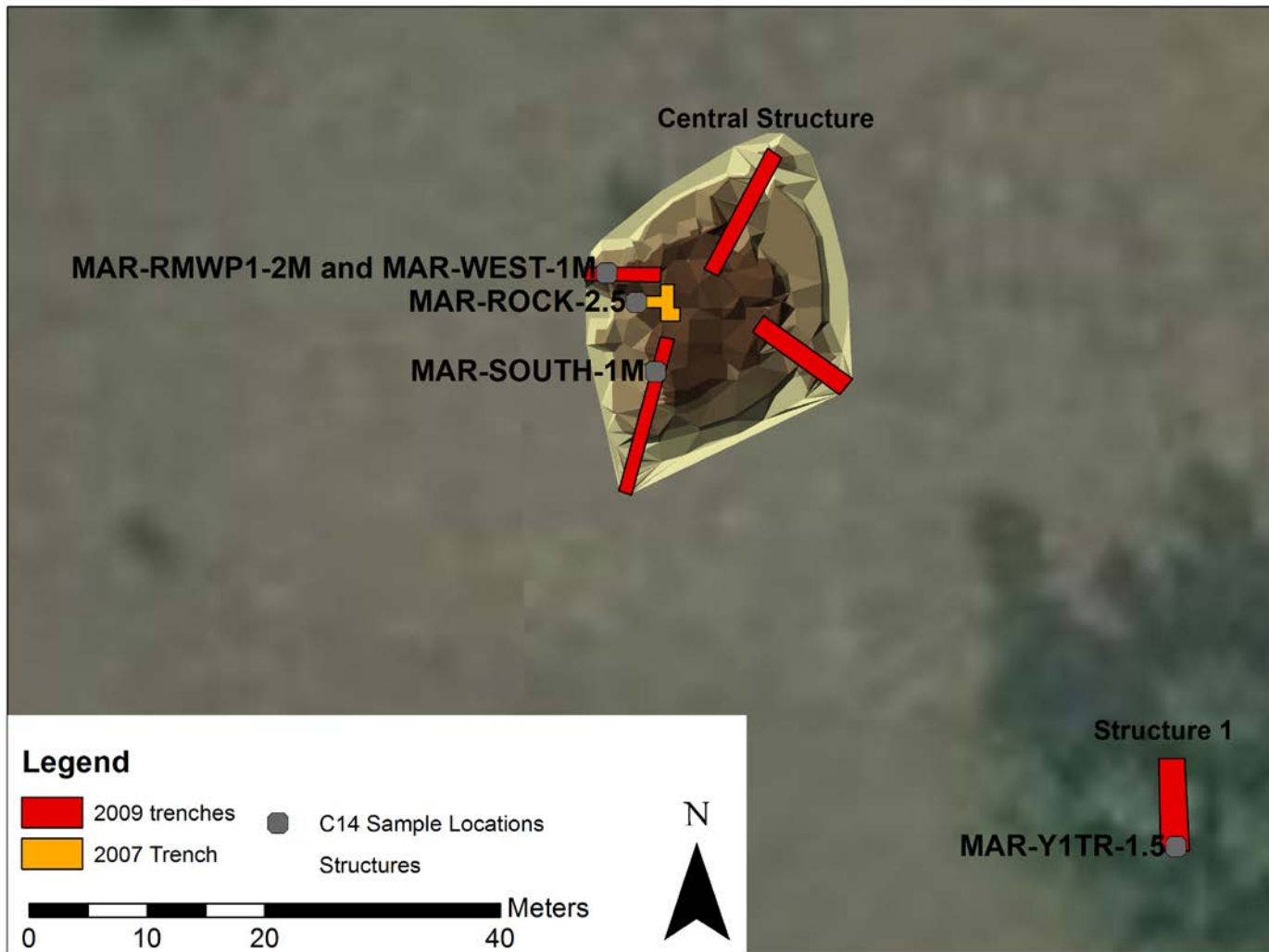


Figure 43. Location of carbon samples central sector of the site.



**Table 7. Radiocarbon Testing Results from La Alberca Structure Complex (2006 and 2009).**

<b>Description</b>	<b>Sample Name</b>	<b>Sample #</b>	<b>Measured date BP</b>	<b>Conventional date BP</b>	<b>plus/minus</b>	<b>Calibrated 2s-hi BP</b>	<b>Calibrated 2s-lo BP</b>
2005 NW Field Pit	MAR-C-NW-50-05	213897	1150 +/- 40 BP	1170	40	1225	975
2005 Structure 13	MAR-C-Y1-90-05	213896	790 +/- 40 BP	780	40	772	666
2009 Structure 1	MAR-Y1TR-1.5	269149	4030 +/- BP	4030	40	4780	4770

**Table 8. Radiocarbon testing results from Central Structure**

<b>Description</b>	<b>Sample Name</b>	<b>Sample #</b>	<b>Measured date BP</b>	<b>Conventional date BP</b>	<b>plus/minus</b>	<b>Calibrated 2s-hi BP</b>	<b>Calibrated 2s-lo BP</b>
2007 Test Pit, 2 meters in depth	MAR-RMWP1-2M	238711	6190 +/- 40 BP	6200	40	7245	6995
2009 South Trench, 1 meter in depth on rock	MAR-SOUTH-1M	269147	4230 +/- 40 BP	4260	40	4870	4820
2009 West Trench, 1 meter in depth	MAR-WEST-1M	269148	5740 +/- BP	5770	40	6660	6470
2009 West Trench, 2.5 meters in depth	MAR-ROCK-2.5	269146	6160 +/- 40 BP	6160	40	7170	6940

## Stratigraphic Profiling

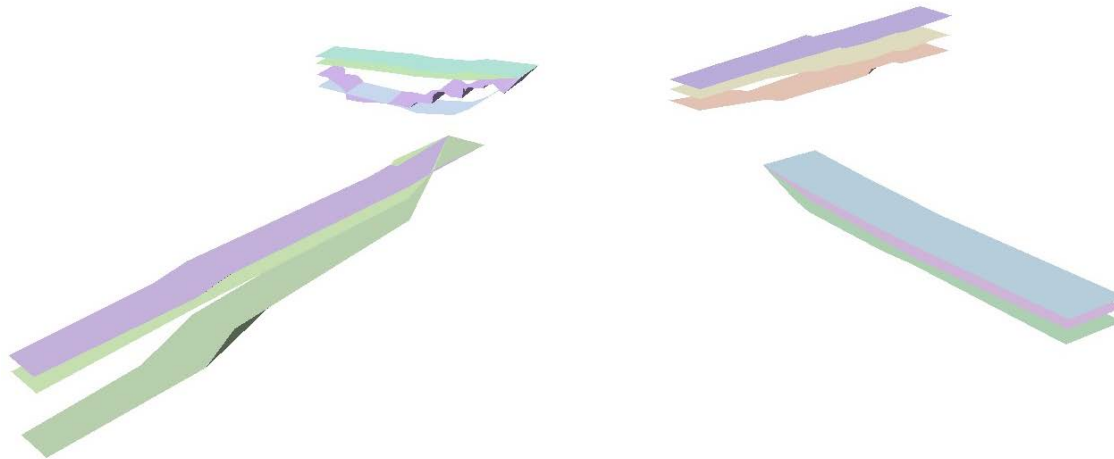
Figure 10 shows a 2.5 meter deep profile wall from the trench excavated on the Central Structure in 2007. The top two strata in the sequence seen in Figure 10 is a top soil mixed with air fall deposited Paricutin ash extending down to about 20 cm or more. Very few artifacts are found within these levels except where rodent burrows and farming activities have disturbed the sediment. These strata sit on top of an old surface which is comprised of a brown silt and is heavily mixed by rodent activity as seen by the presence of krotovina in the profile. Further down there are two strata with diffuse boundaries of orange tephra in varying degrees of degradation. Below the orange sediments is a consolidated (compacted or concreted) tephra, a horizon sometimes culturally referred to as a tepetate; which is a term coined by the Aztecs describing soils that are hardened by compaction or cementation, they are primarily found within volcanic regions (Williams 1972). Beneath this strata there is a consolidated gray-brown tephra, followed by a small rock lens separating it from a layer of unconsolidated tephra which is the deepest and oldest layer observed in the sequence.

## Spatial Mapping

This section reports the results for the various mapping techniques used in order to help answer the first and third Research Questions regarding the stratigraphy of the La Alberca Complex and the shape of the Central Stacked Rock Feature and its method of construction.

### *Spatial Mapping Results: Method 1*

Method one was abandoned after the creation of the first maps using this method as it was immediately apparent that it would not be useful in the interpretation of soil stratigraphy or the shape and construction of the Central Stacked Rock Feature within La Alberca Structure Complex. The results are shown in Figure 44 and Figure 45.



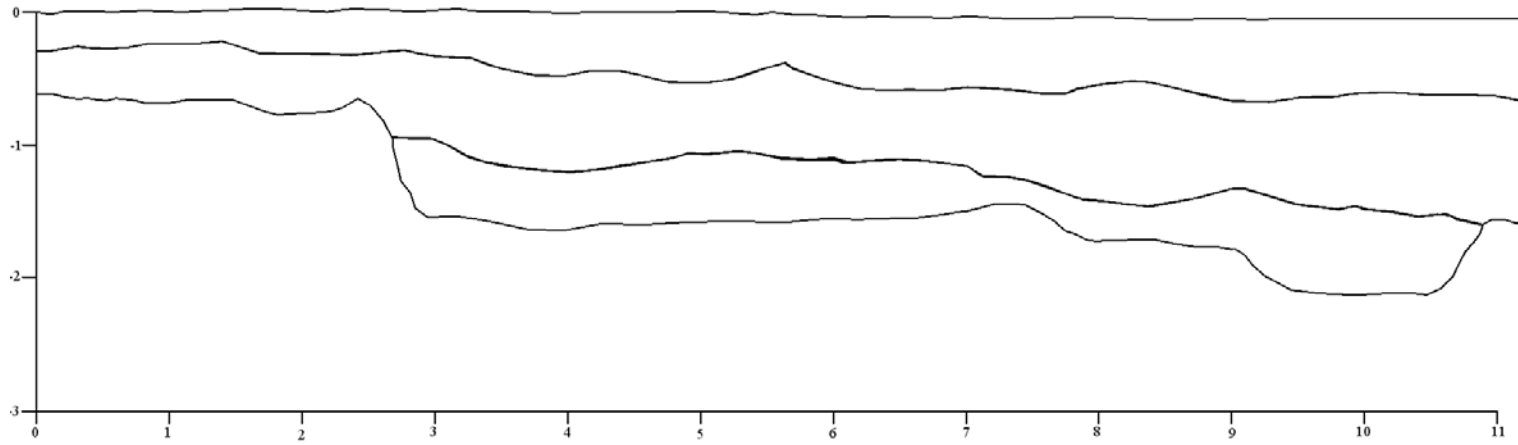
**Figure 44. Method 1 all four trenches (Steinkraus et al. 2013).**



**Figure 45. West Trench Profile Method One (Steinkraus et al. 2013).**

### *Spatial Mapping Results: Method 2*

The following figures demonstrate the final product of the second method utilized for spatial mapping as listed in the Methods section (Figure 46 to Figure 65).



**Figure 46. Digitized profile drawing of the North Trench.**



**Figure 47. Digitized plan map of the North Trench.**

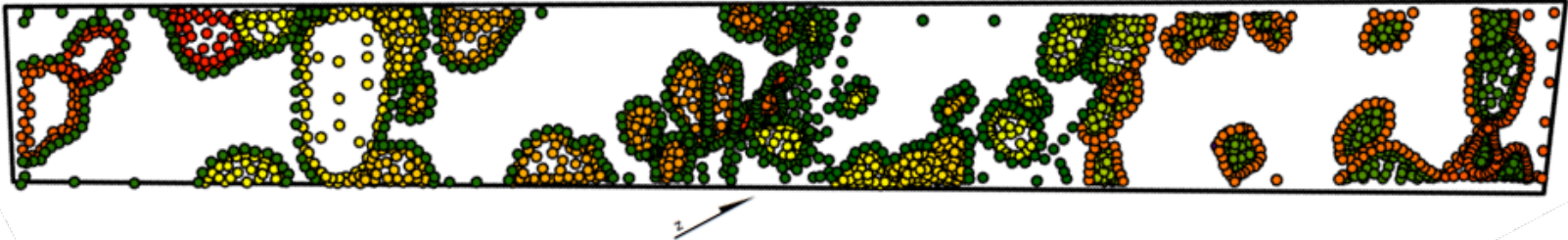


Figure 48. Plan map data points for the North Trench.

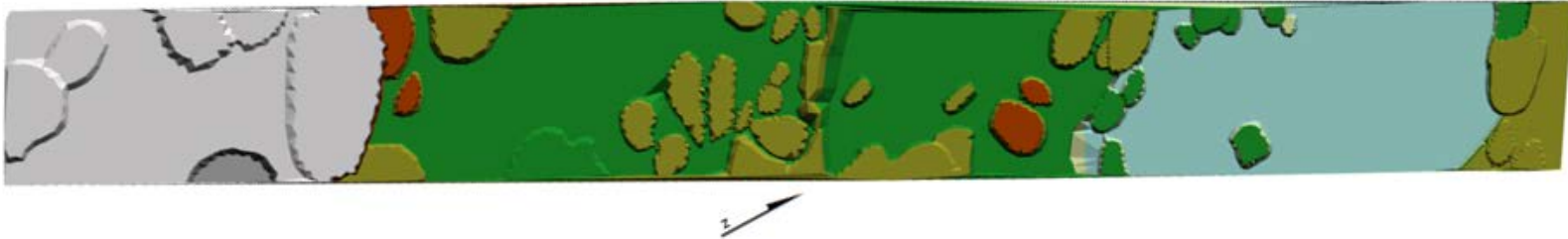
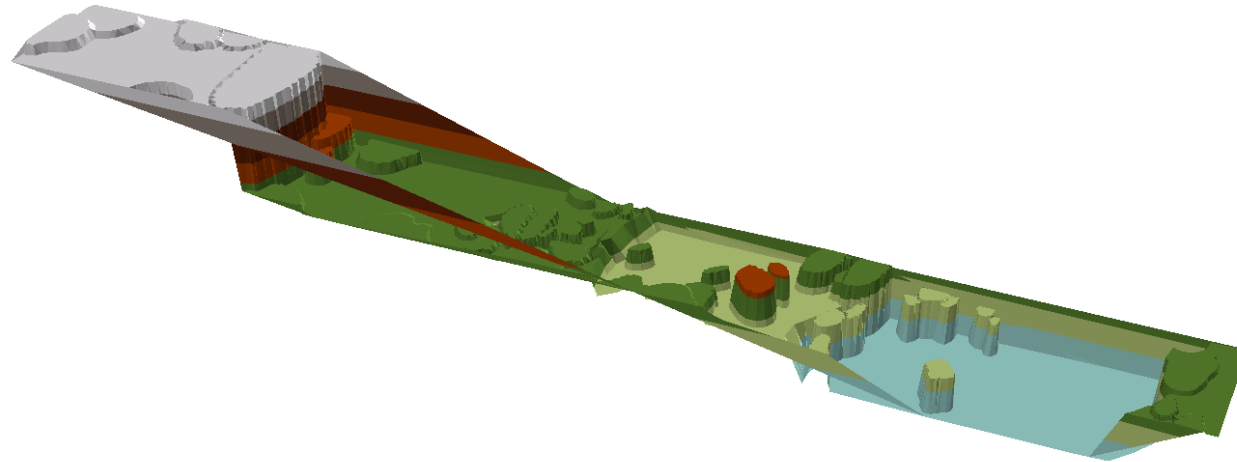
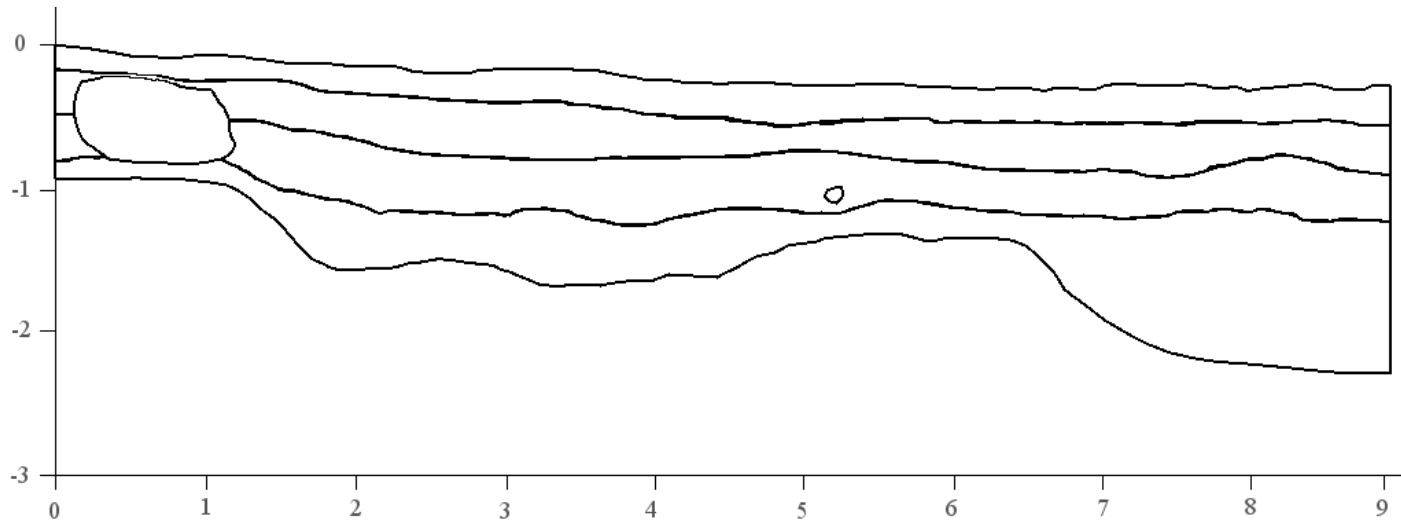


Figure 49. Plan map TIN for the North Trench.

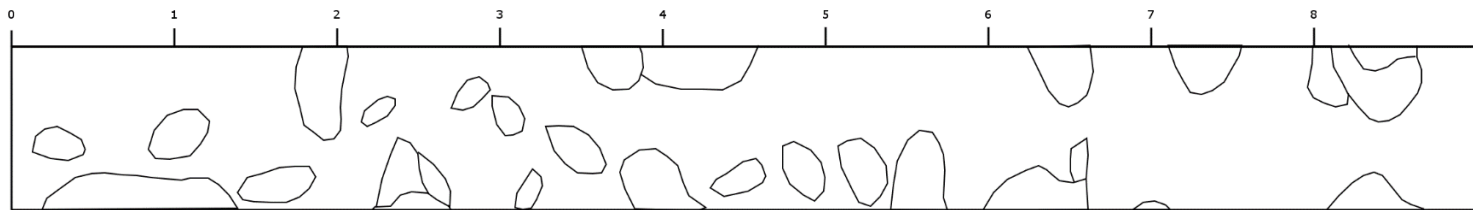




**Figure 50. 3-D rendering of the North Trench.**



**Figure 51. Digitized profile drawing of the East Trench.**



**Figure 52. Digitized plan map of the East Trench**

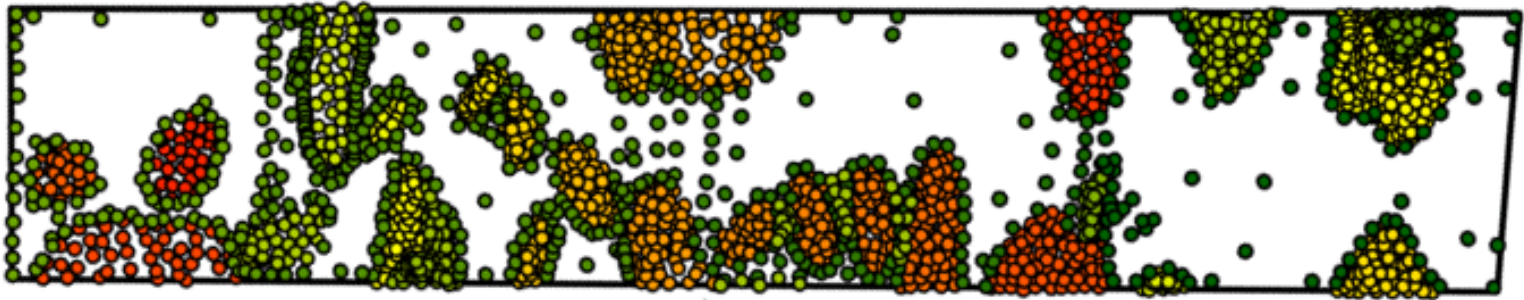
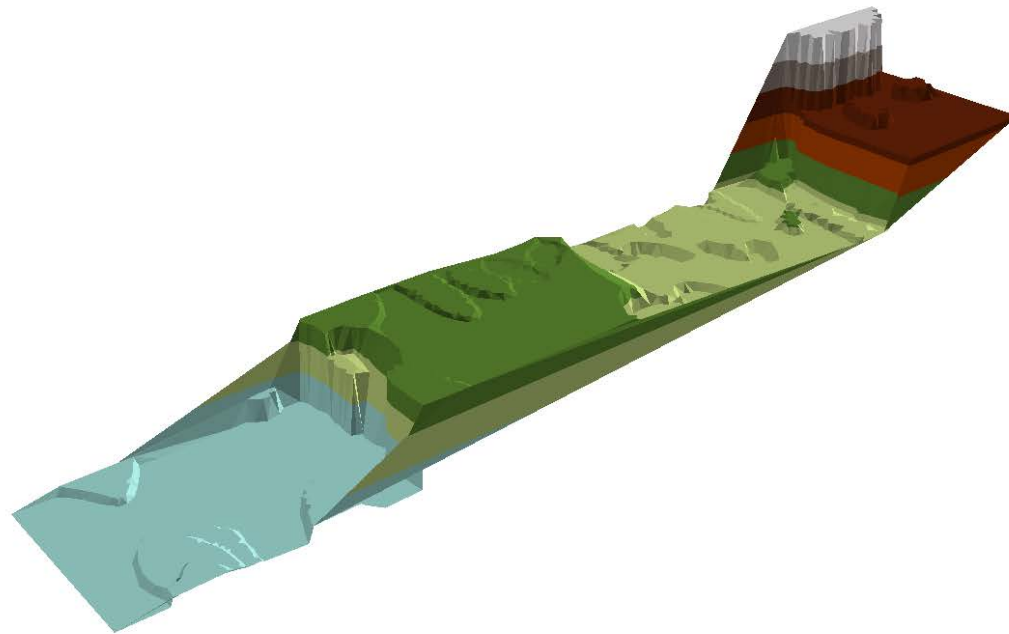


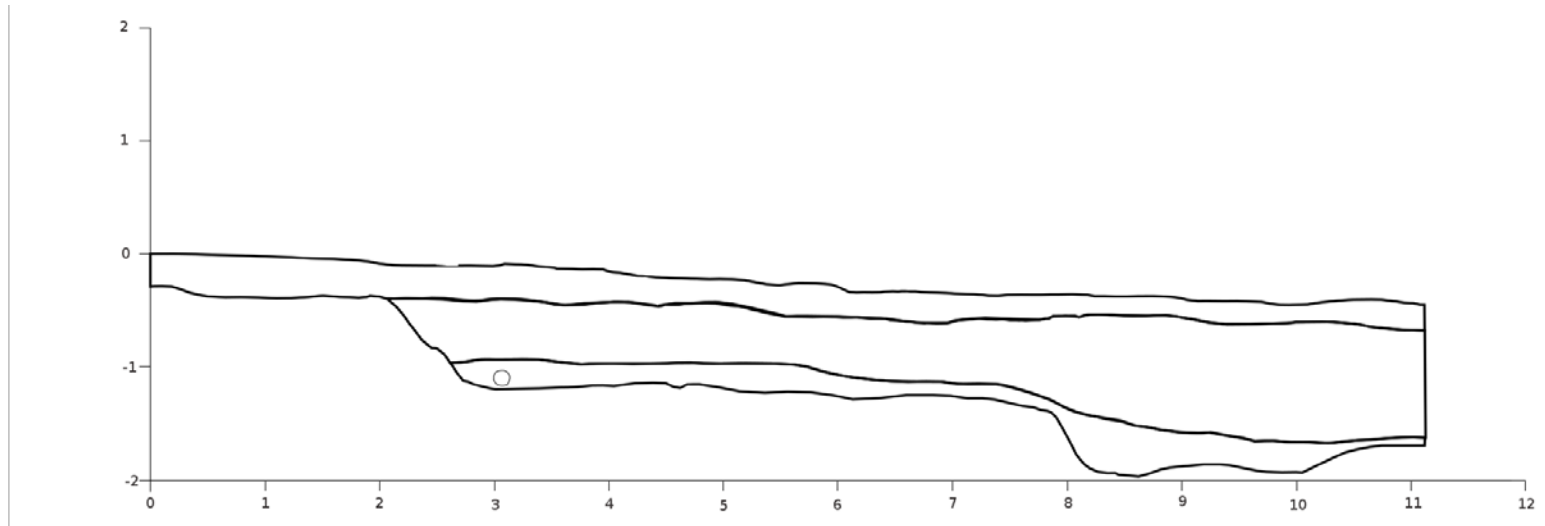
Figure 53. Plan map data points for the East Trench.



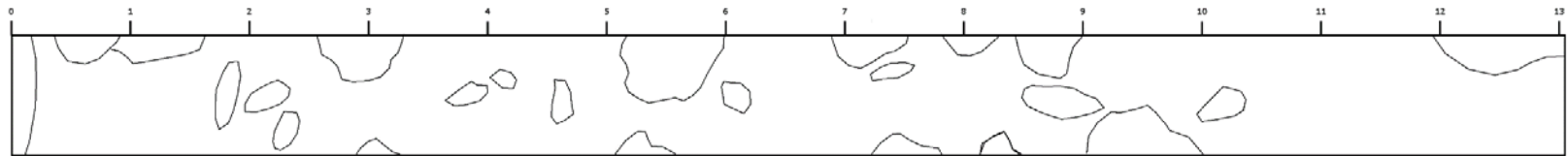
Figure 54. Plan map TIN for the East Trench.



**Figure 55. 3-D rendering of the East Trench.**



**Figure 56. Digitized profile drawing of the South Trench.**



**Figure 57. Digitized plan map of the South Trench.**

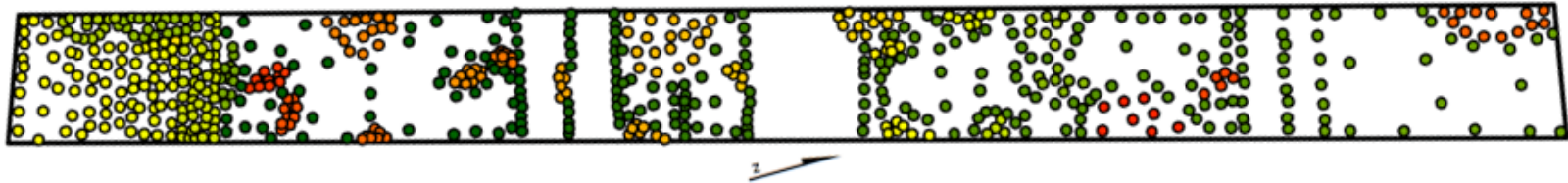


Figure 58. Plan map data points for the South Trench.

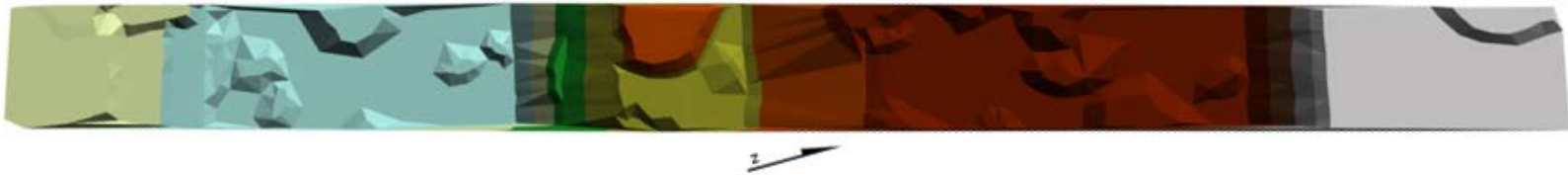
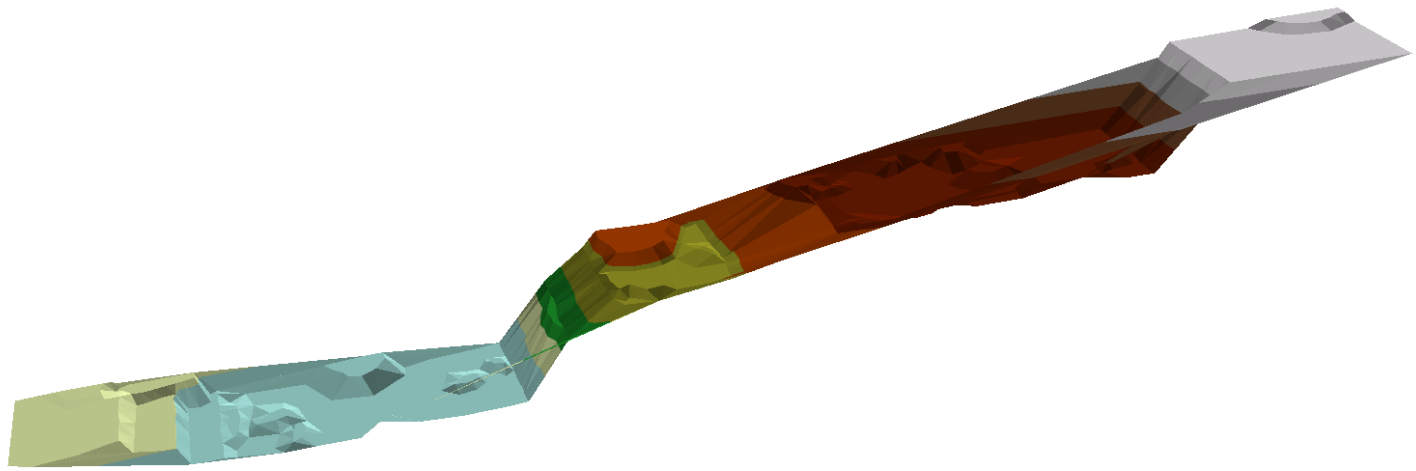
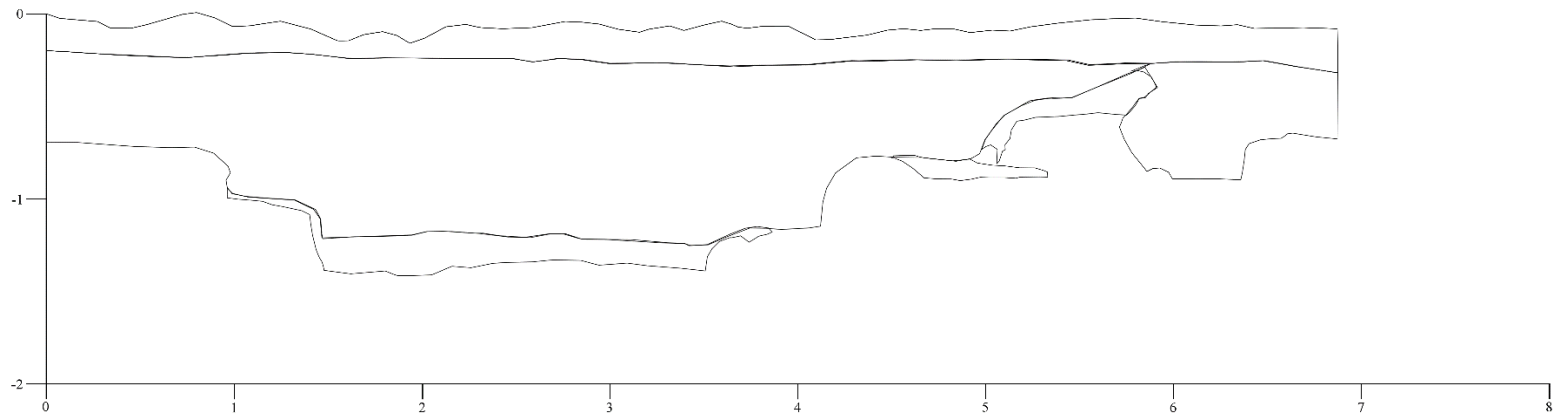


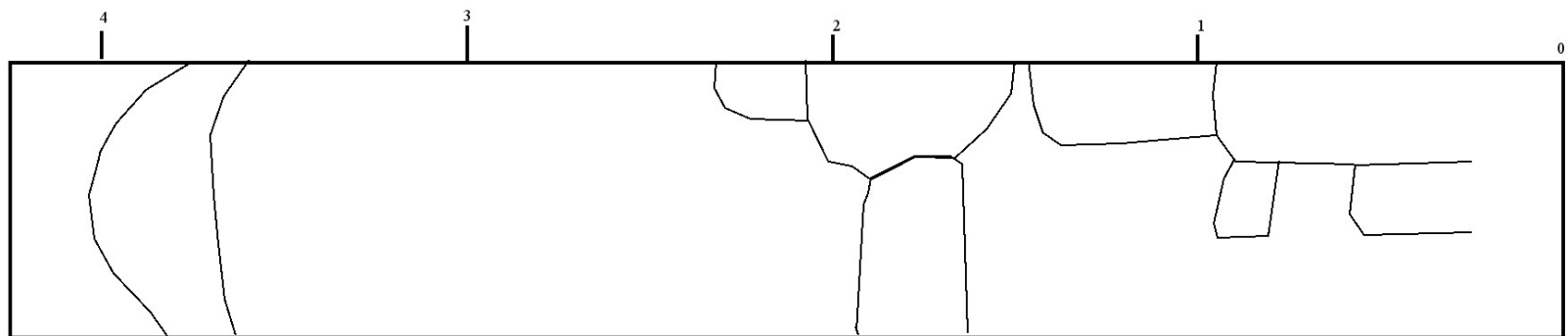
Figure 59. Plan map TIN for the South Trench.



**Figure 60. 3-D rendering of the South Trench.**



**Figure 61. Digitized profile drawing of the West Trench.**



**Figure 62. Digitized plan map of the West Trench.**



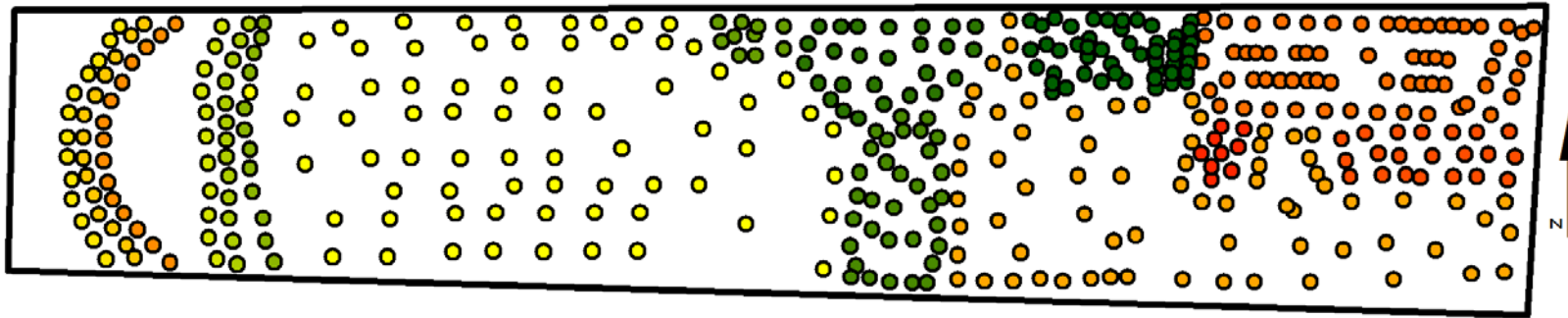


Figure 63. Plan map data points for the West Trench.

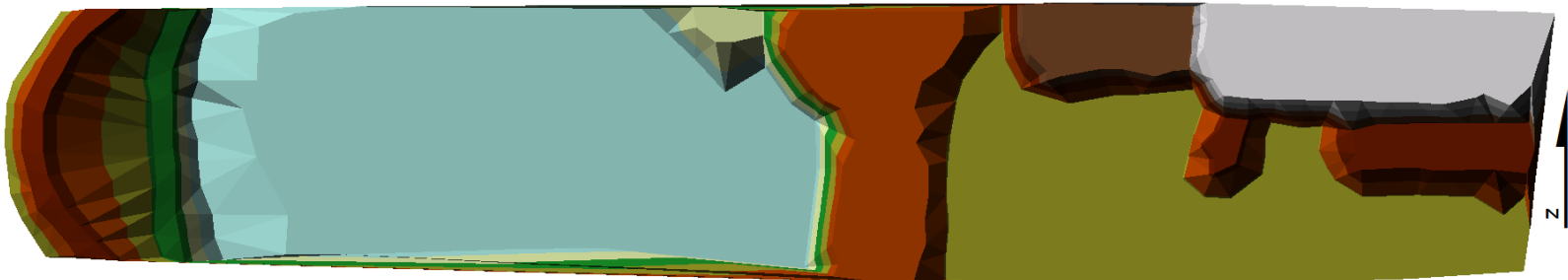
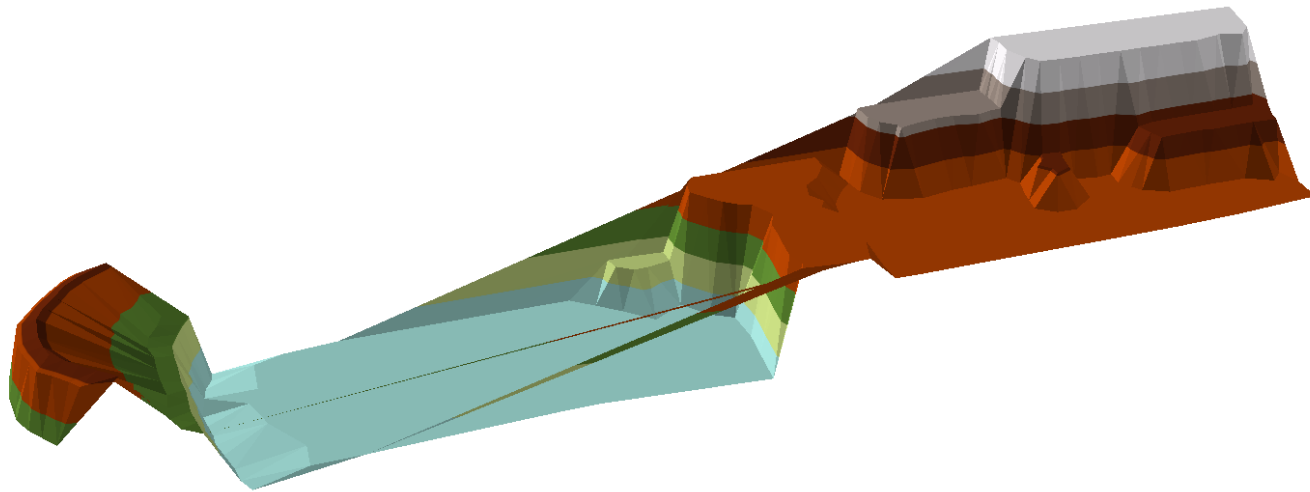


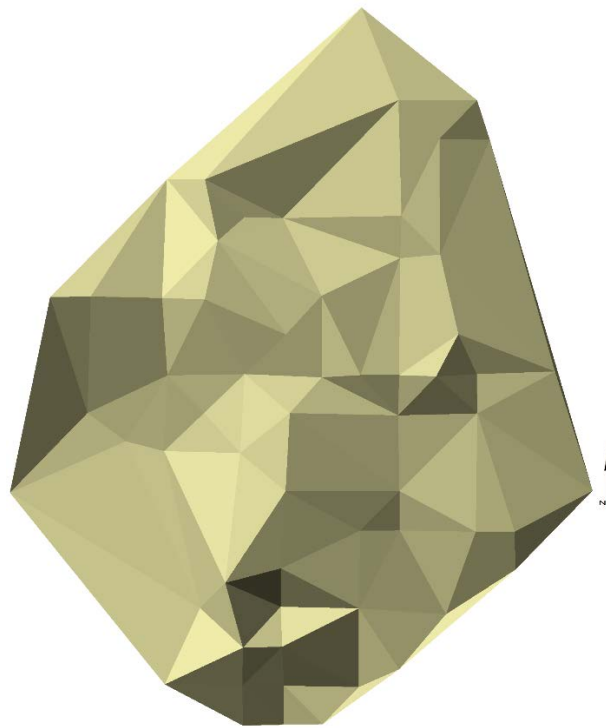
Figure 64. Plan map TIN for the West Trench.



**Figure 65. 3-D rendering of the West Trench.**

### *2013 Data Map*

This section shows the maps created from depth data collected in 2013 from the Central Structure which will help in answering the third Research Question regarding the overall shape of the Central Structure. Limitations to the 2013 depth data include the actual length of the probe used. Shallow false positives, for example pockets of Parícutin tephra, were noted in the field data. Some of these vertices were deleted when they occurred over backfilled trenches.



**Figure 66. 2013 Probe TIN Plan View**



**Figure 67. 2013 Probe TIN Profile View**

## CHAPTER VI.

### DISCUSSION

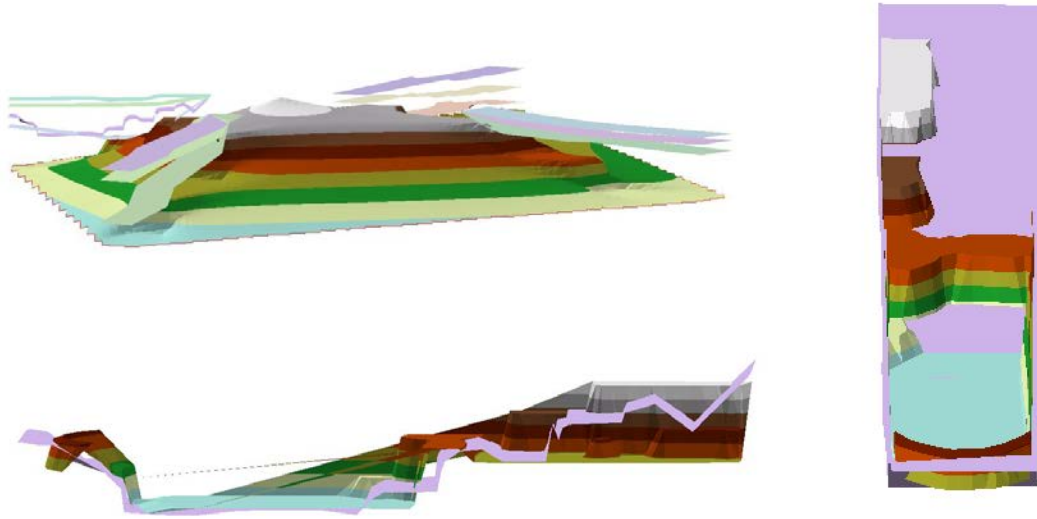
This section includes a discussion comparing spatial mapping methods. This section answers the three research questions presented, and shares recommendations for future research and management.

#### Method 1 versus Method 2

Two methods were developed in order to create similar mapping outcomes. The first method (Method 1) created profile drawings with strong X and Z control. It gave the user more control over what was drawn in the profile. Fewer vertices were required for Method 1 making data entry less time consuming. The visual results from Method 1 were promising, however they lacked any control over Y-values. This method produced successful 3-D imagery by only using 2-D data but lacked any Y control. The amount of user input also increased the potential margin of error (Steinkraus et al. 2013).

The second method (Method 2) incorporated both a plan and profile view of the Central Structure which was turned into a Triangulated Irregular Network (TIN). The Y-value was expressed and calculated, giving a more accurate 3-D rendering of the feature. The TIN method allowed for less error by utilizing more of ArcMap's processing capabilities and reducing human error. This made the end map more accurate to the actual feature depicted. By using field calculator in ArcMap rather than human input, data entry was more automated creating less error. The number of vertex points required in order to create a successful TIN proved to be more time consuming and required a

substantial increase in quality control during data input as opposed to Method 1. One major drawback to using TINs is that it takes more time to rectify mistakes due to the necessity of re-creating the TIN each time data is updated (Steinkraus et al. 2013). See Figure 68 for a comparison of Method 1 and Method 2 maps.



**Figure 68. Upper left image of Method One with previous TIN. Bottom left and right image of West Trench both methods combined (Steinkraus et al. 2013).**

## Research Questions

Through the research conducted for this thesis three overarching questions were addressed. These are discussed in detail below:

### **1) What is the stratigraphy of La Alberca Structure Complex and related sites?**

The stratigraphy of La Alberca Structure Complex has been well documented over 13 years of site visits. Analysis of stratigraphic profiles from test units and cutbanks exposed on and off site have been woven together to complete a comprehensive geological chronology dating from 7000 to 1950 years B.P. Volcanic depositional events that are found buried between strata leave a unique signature and prove to be an excellent tool in giving a time range for cultural and natural features buried between them. The oldest sediments observed at La Alberca Structure Complex is a coarse black tephra that has also been observed at La Alberca Caldera Rockshelter as well as a steep roadcut located between the sites.

Sediments just above this tephra layer were radiocarbon dated at La Alberca Caldera Rockshelter site and was found to be older than 6500 years B.P. La Alberca Structure Complex's Central Stacked Rock Feature was found buried beneath orange consolidated tephra. This stratum was also noted above Yacata 1 and after cross-site analysis it was determined that this tephra was most likely deposited over 4000 years B.P.

**2) What is the age of the Central Structure in comparison to the other structures found at the Structure Complex and in relation to La Alberca Caldera Rockshelter?**

Organic material from seven locations within La Alberca Structure Complex have been radiocarbon dated by Beta Labs. Four of the seven samples that were dated, were associated with the Central Stacked Rock Feature. Two of the samples came from Yacata 13, and the last sample came from the Northwest Pit which was excavated in 2005.

The closest associated sample to the Central Stacked Rock Feature is from sample MAR-WEST-1M. This consisted of a two to three centimeter resinous charcoal chunk that was found directly on top of a rock making up part of the Central Stacked Rock Feature within the West Trench. This sample was dated to 6660 to 6470 cal B.P. Samples ELMARRMWP12m and MAR-ROCK-2.5 gave the oldest dates for the structure, these samples fall within 7245 to 6940 cal B.P.

The South Trench sample MAR-SOUTH-1M date range was younger, returning an age range of 4870 to 4820 cal B.P. This later date may be a result of continuous use of this structure from approximately 7245 to 4800 cal B.P. Three out of the four samples tested from the Central Stacked Rock Feature fell within 800 years of each other, strengthening the argument that the radiocarbon dates are accurate.

The presence of temporally diagnostic ceramic artifacts located on and around the other yacatas within the La Alberca Structure Complex correspond well with the Northwest Pit radiocarbon date of 1225 to 975 cal B.P. Yacata 13 has a date range of

4780 to 666 cal B.P., suggesting continuous use and habitation during that timeline. The Central Stacked Rock Feature was void of ceramic artifacts. This fits with the date range indicated by radiocarbon dating which predates ceramics in this region (Kennett et al. 2010).

This leads to the conclusion that the Central Structure (7245-4800 cal B.P.) is significantly older than the surrounding structures of La Alberca Structure Complex which produced radiocarbon dates to the Postclassic Period (1000-1520 C.E.) (Gabany-Guerrero et al. 2015). The dates for the Central Structure also overlap with the dates for the burial in La Alberca Caldera Rockshelter (6650-3985 cal B.P.; Figure 8) although the Central Structure apparently predates the burial by approximately 600 years.

Radiocarbon dating of charcoal remnants found within the Central Structure produced results that established an extremely ancient date range, making the Central Structure found at La Alberca Structure Complex quite possibly the oldest rock and earth structural feature in Western Mexico (Hackenberger et al. 2006; Hackenberger et al. 2010).

### **3) What is the shape of the Central Structure? What hypotheses can we form about the function of the Central Structure?**

Based on the maps created from the data available, it appears that the Central Stacked Rock Feature was built on top of, rather than into, the landform. The structure is approximately 24 meters by 32 meters in width and approximately three meters in height. There appears to be an overall northeast/southwest orientation to the structure and it



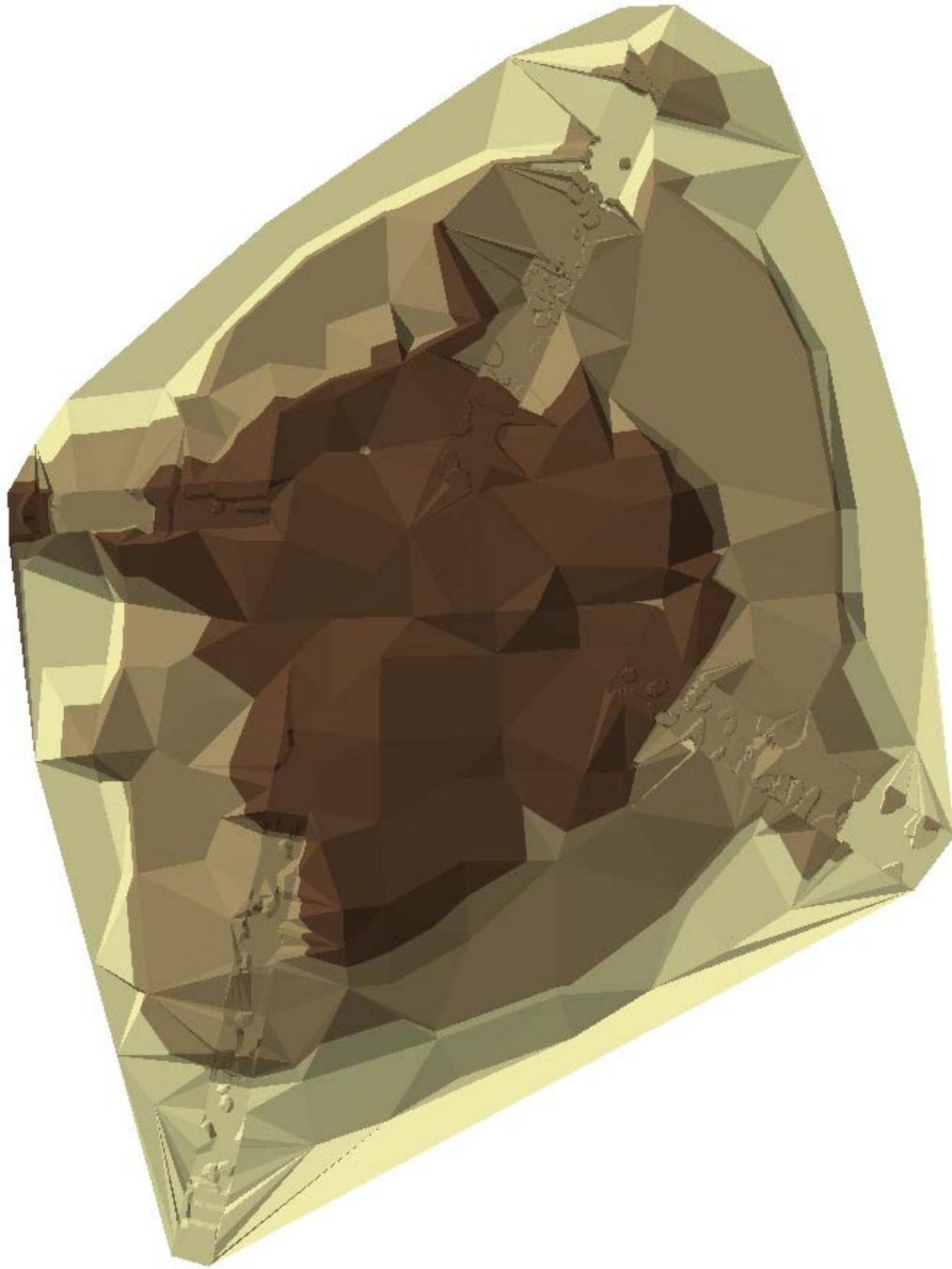
seems to be more oval/spheroid in shape as opposed to rectangular. The structure looks to include three or four tiers (steps or terraces) at least one of which is consistently five meters in width across three sides of the feature (Figure 69). Each tier is between 60 and 90 centimeters in height.

Erratic depths at the top of the structure indicate that the upper portion of the feature was likely damaged either by intentional removal (mining) of stones in the precontact and/or historic periods or through agricultural activities (planting of fruit trees and/or field clearing) in the field above. The builders of the Central Stacked Rock Feature used rock walls backfilled with sediments to construct the feature.

This construction type necessitates a closer look at the radiocarbon dates obtained from the structure. Table 9 illustrates that older sediments were not being used as the fill within the structure as shown by the placement of radiocarbon dates stratigraphically.

The youngest sample taken over the feature (MAR-SOUTH-1M) was located at 1 meter below the ground surface. This piece of resinous charcoal was located directly on top of a rock that was part of the original surface of the structure. The two older dates both come from deeper within the stratigraphy. If older sediments were used as back fill (thus contaminating stratigraphic dating), older dates would be found higher in the structure than newer dates as the borrow location where the fill soil was extracted from increased in depth. The age estimate for the 1.5 meter deep sample from Structure 1,

MAR-Y1TR-1.5, matches the age estimate for the sample from the rock surface of the Central Structure.



**Figure 69. Tin created with data points from method 2 and 2013 data points.**

**Table 9. Depths of radiocarbon samples from the Central Structure and Structure 1.**

<b>Sample Name</b>	<b>Depth (meter)</b>	<b>Age Range (cal BP)</b>
Central Structure MAR-SOUTH-1M	1	4820 to 4870
Central Structure MAR-WEST-1M	1	6470 to 6660
Central Structure MAR-ROCK-2.5	2.5	6940 to 7170
Central Structure MAR-RMWP1-2m	2.3	6995 to 7245
Structure 1 MAR-Y1TR-1.5	1.5	4030 to 4770

## CHAPTER VII.

### CONCLUSIONS

The structures analyzed in this thesis appear to be the oldest known stone and earth structures in West Mexico. Carbon dates from the Central Stacked Rock Feature show this structure to be 7000 to 6000 years old and that it may have been in use as recently as 5000 to 4000 years ago (in calibrated radiocarbon years). These structures are likely precursors to the late formative *guachomontanes*, and may cover burials if not shaft tombs.

West Central Mexico has now been identified as the home of the closest genetic relatives to maize and beans and includes the earliest archaeological evidence for maize (Piperno et al. 2000). It follows to hypothesize that early sedentism and early public structures would also develop within this region. Test trenching and probing, when combined with 3-D ArcMap visualization, reveal important details about the fully buried Central Rock Feature. It appears to have been built on top of, rather than into an elevated natural landform with three tiers with rock walls backfilled with sediments to form gently sloping steps or terraces. The middle tier is consistently five meters in width. Each tier is between 60 and 90 cm high. The structure is ovoid in shape with a NE-SW orientation. The Central Structure is devoid of archaeological artifacts. The earliest ceramic sherds recovered from the Structure Complex (50-80 centimeters deep) are found above the lower tephras (1-2.5 meters deep) that superimpose rock construction.

The Late Archaic ritual burial in the La Alberca Caldera Rockshelter and the early construction of ceremonial mounds in the La Alberca Structure Complex, on lands managed by the Comunidad Indígena de Nuevo San Juan Parangaricutiro, together predate similar developments in the Early Formative Period in West Mexico and elsewhere. The burial and preservation of rock features in the Parangaricutiro Highlands by tephra from several eruptions provides challenges for geoarchaeologists and tephrochronologists who need to refine models of the nature and extent of the influences of volcanoes on early cultural developments.

Ongoing collaborations with the Comunidad Indígena de Nuevo San Juan Parangaricutiro hold great potential for exploring the origins of sedentary ranked communities that predate others in Mesoamerica by as much as one thousand years. The findings presented through this research have provided the academic community information that was previously unavailable in this region. This data, along with related studies of this area, allow for a better understanding of the chronology of human settlement in the Americas and how organized cultural systems developed and evolved in Mesoamerica (Gabany-Guerrero et al. 2015; Hackenberger et al. 2006). These advancements in understanding the early inhabitation and development of the Americas would not have been possible without elder and community member involvement from the Comunidad Indígena de Nuevo San Juan Parangaricutiro (Drozdowski 2014).

## Recommendations

Archaeological sites like the Structure Complex with well-preserved Late Archaic Period monuments such as the Central Structure are no doubt rare. When discovered it is important that they be fully researched and or protected. I outline my recommendations under three categories: site exploration and excavation, sample and artifact analysis, and site management.

The site should be full explored using ground penetrating radar in open areas between structures and over each structure. Each major structure should be hand trenched and some effort should be made to determine if shaft and chambers are located under the boulder features and tiered structures. Although near surface artifacts were located in some sectors of the site, it would be important to determine if there are any deeper occupation areas with debris that might date to the Archaic Period.

In order to further understand the transition into the Early Formative Period, samples and artifacts from around the Central Structure and other early structures should be analyzed with a full complement of methods including: tephra identification, argon-argon dating of tephra, luminescence dating of ceramics, and or suitable sediment matrix. Pollen and phytoliths should be recovered from some of the sediments to test for the presence of squash, teosinte, and maize. Deep coring of lakes and wetlands within the region will also create a better chronology of sediments. The analysis of pollen and phytoliths from these cores will contribute to understandings of regional climate change, fire ecology, and other anthropogenic changes associated with transitions to economies based on sedentism, agriculture and ritual organization within and between communities.

It is my recommendation that looted and excavated stone structures be reconstructed and the areas be developed and interpreted as a park. This effort might develop as a partnership between INAH, the city of San Juan Nuevo, and the Comunidad Indigena de Parangaricutiro. The location could be staffed as an extension of the forest reserve check point and/or the Panzingo Ecotourism Center. Staffing should lend extra protection of the pictographs at La Alberca Rockshelter. If not fully excavated and reconstructed, structures might be protected with caps of timber, rock, and Paracutin tephra, to preserve and protect features. If site structures are reconstructed, benefits to the communities would include a greater understanding and appreciation for local history, a better public understanding of the Comunidad Indigena de Parangaricutiro's cultural history, and economic benefits through additional ecotourism.

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## APPENDIXES

### Appendix A -- RadioCarbon Dating Results





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**Darden Hood**  
President  
**Ronald Hatfield**  
**Christopher Patrick**  
Deputy Directors

December 15, 2009

Dr. Steven Hackenberger  
Central Washington University  
Department of Anthropology and Museum  
400 East University Ave  
Ellensburg, WA 98926-7544  
USA

RE: Radiocarbon Dating Results For Samples MAR-ROCK-2.5, MAR-SOUTH-1M, MAR-WEST-1M,  
MAR-Y1TR-1.5, TV-TALL-1.2m, TVTESTPLAT80

Dear Dr. Hackenberger:

Enclosed are the radiocarbon dating results for six samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent electronically. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file



**BETA ANALYTIC INC.**

DR. M.A. TAMERS and MR. D.G. HOOD

4985 S.W. 74 COURT  
MIAMI, FLORIDA, USA 33155  
PH: 305-667-5167 FAX:305-663-0964  
beta@radiocarbon.com

## REPORT OF RADIOCARBON DATING ANALYSES

Dr. Steven Hackenberger

Report Date: 12/15/2009

Central Washington University

Material Received: 11/20/2009

Sample Data	Measured Radiocarbon Age	<sup>13</sup> C/ <sup>12</sup> C Ratio	Conventional Radiocarbon Age(*)
Beta - 269146 SAMPLE : MAR-ROCK-2.5 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 5220 to 4990 (Cal BP 7170 to 6940)	6160 +/- 40 BP	-25.0 o/oo	6160 +/- 40 BP
Beta - 269147 SAMPLE : MAR-SOUTH-1M ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2920 to 2870 (Cal BP 4870 to 4820) AND Cal BC 2800 to 2780 (Cal BP 4740 to 4730)	4230 +/- 40 BP	-23.4 o/oo	4260 +/- 40 BP
Beta - 269148 SAMPLE : MAR-WEST-1M ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 4720 to 4520 (Cal BP 6660 to 6470)	5740 +/- 40 BP	-23.3 o/oo	5770 +/- 40 BP
Beta - 269149 SAMPLE : MAR-Y1TR-1.5 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2830 to 2820 (Cal BP 4780 to 4770) AND Cal BC 2630 to 2470 (Cal BP 4580 to 4420)	4030 +/- 40 BP	-24.7 o/oo	4030 +/- 40 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the <sup>14</sup>C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby <sup>14</sup>C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured <sup>13</sup>C/<sup>12</sup>C ratios (delta <sup>13</sup>C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta <sup>13</sup>C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta <sup>13</sup>C, the ratio and the Conventional Radiocarbon Age will be followed by \*\*\*. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.



**BETA ANALYTIC INC.**

DR. M.A. TAMERS and MR. D.G. HOOD

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beta@radiocarbon.com

## REPORT OF RADIOCARBON DATING ANALYSES

Dr. Steven Hackenberger

Report Date: 12/15/2009

Sample Data	Measured Radiocarbon Age	$^{13}\text{C}/^{12}\text{C}$ Ratio	Conventional Radiocarbon Age(*)
Beta - 269150 SAMPLE : TV-TALL-1.2m ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 660 to 880 (Cal BP 1280 to 1070)	1260 +/- 40 BP	-25.1 o/oo	1260 +/- 40 BP
Beta - 269151 SAMPLE : TVTESTPLAT80 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1210 to 1290 (Cal BP 740 to 660)	750 +/- 40 BP	-24.0 o/oo	770 +/- 40 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the  $^{14}\text{C}$  activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby  $^{14}\text{C}$  half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured  $^{13}\text{C}/^{12}\text{C}$  ratios (delta  $^{13}\text{C}$ ) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta  $^{13}\text{C}$ . On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta  $^{13}\text{C}$ , the ratio and the Conventional Radiocarbon Age will be followed by \*\*\*. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25;lab.mult=1)

Laboratory number: **Beta-269146**

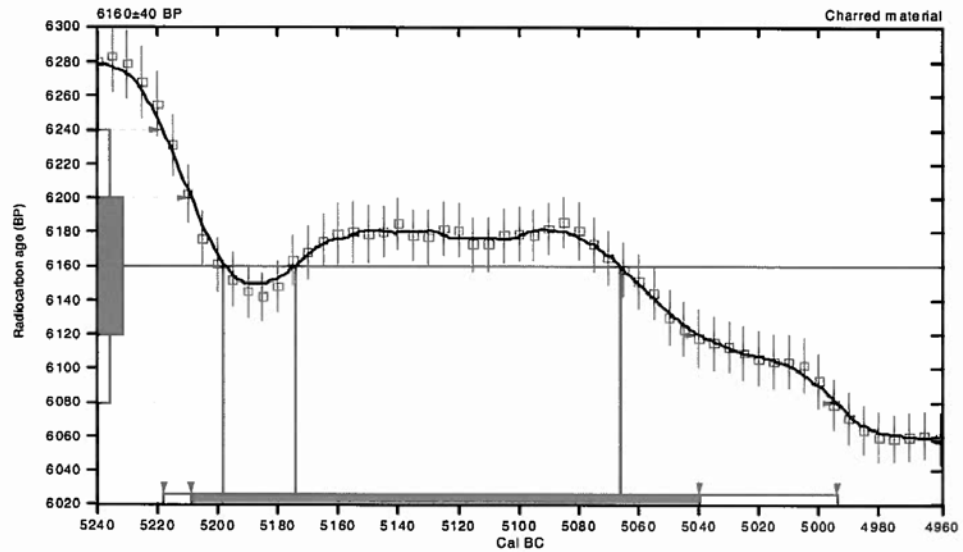
Conventional radiocarbon age: **6160±40 BP**

**2 Sigma calibrated result: Cal BC 5220 to 4990 (Cal BP 7170 to 6940)**  
(95% probability)

Intercept data

Intercepts of radiocarbon age  
with calibration curve: Cal BC 5200 (Cal BP 7150) and  
Cal BC 5170 (Cal BP 7120) and  
Cal BC 5070 (Cal BP 7020)

**1 Sigma calibrated result: Cal BC 5210 to 5040 (Cal BP 7160 to 6990)**  
(68% probability)



### References:

*Database used*  
INTCAL04  
*Calibration Database*  
INTCAL04 Radiocarbon Age Calibration  
*IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*  
*Mathematics*  
*A Simplified Approach to Calibrating C14 Dates*  
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

## Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-269147**

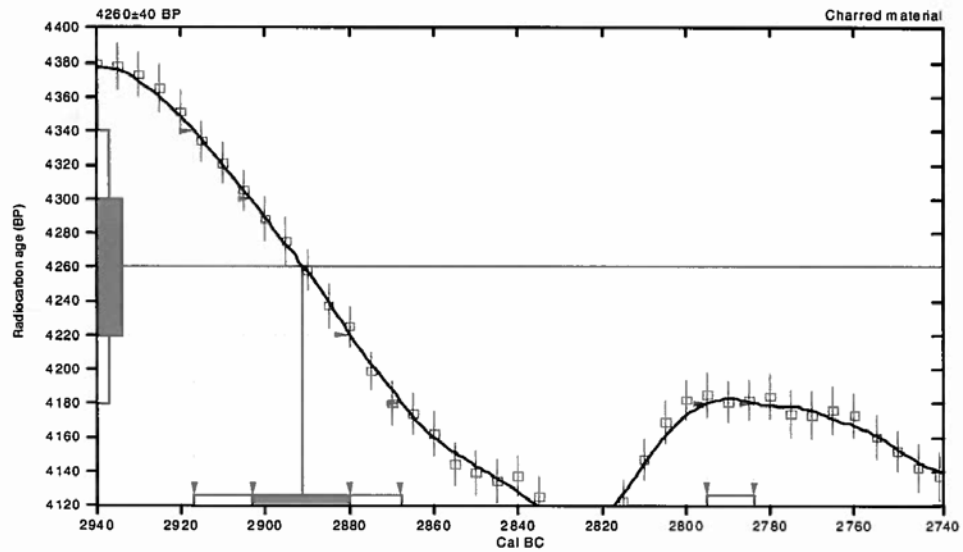
Conventional radiocarbon age: **4260±40 BP**

2 Sigma calibrated results: **Cal BC 2920 to 2870 (Cal BP 4870 to 4820) and  
(95% probability) Cal BC 2800 to 2780 (Cal BP 4740 to 4730)**

Intercept data

Intercept of radiocarbon age  
with calibration curve: **Cal BC 2890 (Cal BP 4840)**

1 Sigma calibrated result: **Cal BC 2900 to 2880 (Cal BP 4850 to 4830)  
(68% probability)**



### References:

Database used  
*INTCAL04  
Calibration Database  
INTCAL04 Radiocarbon Age Calibration  
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*  
Mathematics  
*A Simplified Approach to Calibrating C14 Dates  
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322*

### Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.3:lab. mult=1)

Laboratory number: **Beta-269148**

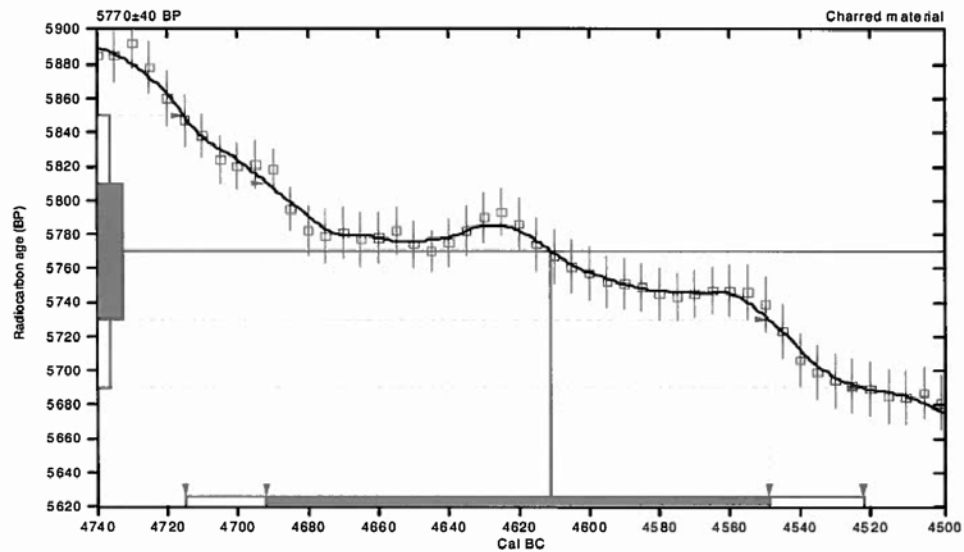
Conventional radiocarbon age: **5770±40 BP**

**2 Sigma calibrated result: Cal BC 4720 to 4520 (Cal BP 6660 to 6470)**  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal BC 4610 (Cal BP 6560)

**1 Sigma calibrated result: Cal BC 4690 to 4550 (Cal BP 6640 to 6500)**  
(68% probability)



### References:

*Database used*  
INTCAL04  
*Calibration Database*  
INTCAL04 Radiocarbon Age Calibration  
*IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*

*Mathematics*  
*A Simplified Approach to Calibrating C14 Dates*  
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.7;lab. mult=1)

Laboratory number: **Beta-269149**

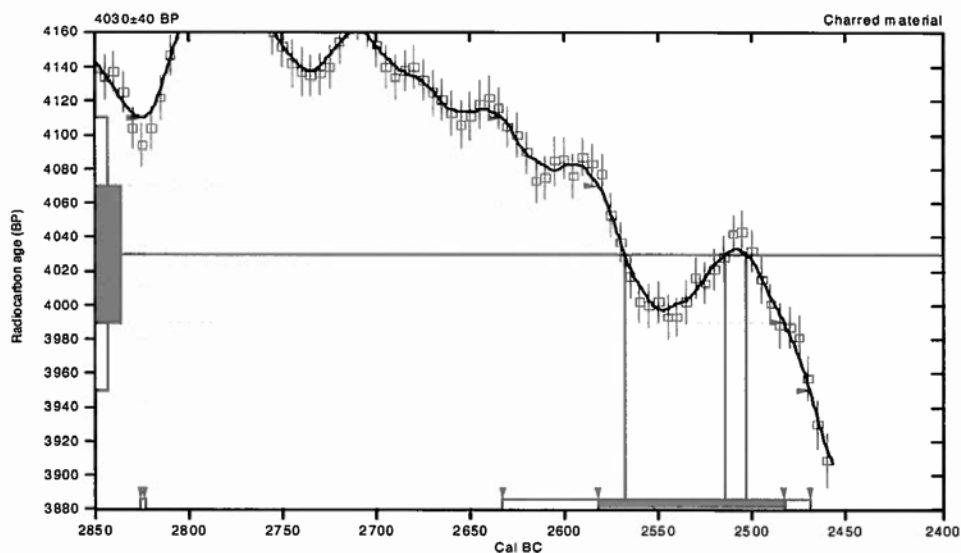
Conventional radiocarbon age: **4030±40 BP**

2 Sigma calibrated results: **Cal BC 2830 to 2820 (Cal BP 4780 to 4770) and  
(95% probability) Cal BC 2630 to 2470 (Cal BP 4580 to 4420)**

Intercept data

Intercepts of radiocarbon age  
with calibration curve: **Cal BC 2570 (Cal BP 4520) and  
Cal BC 2510 (Cal BP 4460) and  
Cal BC 2500 (Cal BP 4450)**

1 Sigma calibrated result: **Cal BC 2580 to 2480 (Cal BP 4530 to 4430)  
(68% probability)**



### References:

Database used  
*INTCAL04  
Calibration Database  
INTCAL04 Radiocarbon Age Calibration  
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*

Mathematics  
*A Simplified Approach to Calibrating C14 Dates  
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322*

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.1:lab. mult=1)

Laboratory number: **Beta-269150**

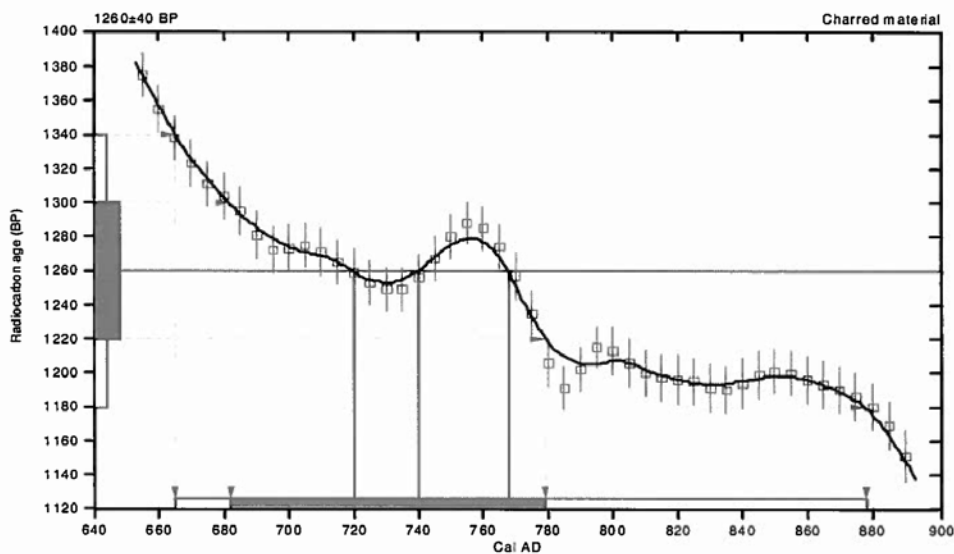
Conventional radiocarbon age: **1260±40 BP**

**2 Sigma calibrated result: Cal AD 660 to 880 (Cal BP 1280 to 1070)**  
(95% probability)

Intercept data

Intercepts of radiocarbon age  
with calibration curve: Cal AD 720 (Cal BP 1230) and  
Cal AD 740 (Cal BP 1210) and  
Cal AD 770 (Cal BP 1180)

**1 Sigma calibrated result: Cal AD 680 to 780 (Cal BP 1270 to 1170)**  
(68% probability)



### References:

Database used  
*INTCAL04*  
Calibration Database  
*INTCAL04 Radiocarbon Age Calibration*  
*IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*  
Mathematics  
*A Simplified Approach to Calibrating C14 Dates*  
Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24;lab. mult=1)

Laboratory number: **Beta-269151**

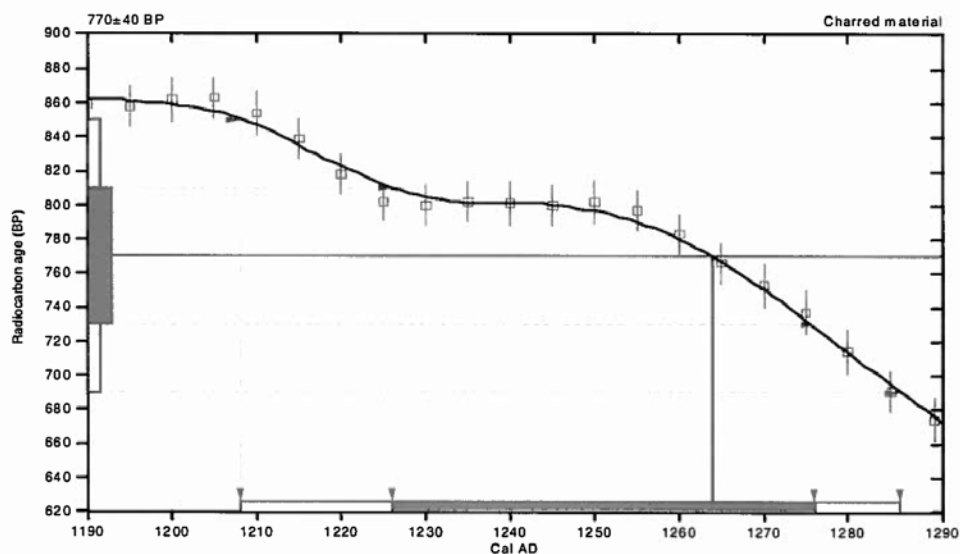
Conventional radiocarbon age: **770±40 BP**

**2 Sigma calibrated result: Cal AD 1210 to 1290 (Cal BP 740 to 660)**  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal AD 1260 (Cal BP 690)

**1 Sigma calibrated result: Cal AD 1230 to 1280 (Cal BP 720 to 670)**  
(68% probability)



### References:

- Database used*  
*INTCAL04*  
*Calibration Database*  
*INTCAL04 Radiocarbon Age Calibration*  
*IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*
- Mathematics*  
*A Simplified Approach to Calibrating C14 Dates*  
*Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322*

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Delivered On Time

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Tel: 305-667-5167  
Fax: 305-663-0964  
beta@radiocarbon.com  
www.radiocarbon.com

**Mr. Darden Hood**  
President

**Mr. Ronald Hatfield**  
**Mr. Christopher Patrick**  
Deputy Directors

*The Radiocarbon Laboratory Accredited to ISO-17025 Testing Standards (PJLA Accreditation #59423)*

## Final Report

The final report package includes the final date report, a statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. The final report has been sent by mail and e-mail (where available).

## Pretreatment

Pretreatment methods are reported along with each result. All necessary chemical and mechanical pretreatments of the submitted material were applied at the laboratory to isolate the carbon, which may best represent the time event of interest. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated, making their  $^{14}\text{C}$  ages more subjective than samples, which can be fully pretreated. Some materials receive no pretreatments. Please look at the pretreatment indicated for each sample and read the pretreatment glossary to understand the implications.

## Analysis

Materials measured by the radiometric technique were analyzed by synthesizing sample carbon to benzene (92% C), measuring for  $^{14}\text{C}$  content in one of 53 scintillation spectrometers, and then calculating for radiocarbon age. If the Extended Counting Service was used, the  $^{14}\text{C}$  content was measured for a greatly extended period of time. AMS results were derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite was then detected for  $^{14}\text{C}$  content in one of 9 accelerator-mass-spectrometers (AMS).

## The Radiocarbon Age and Calendar Calibration

The "Conventional  $^{14}\text{C}$  Age (\*)" is the result after applying  $^{13}\text{C}/^{12}\text{C}$  corrections to the measured age and is the most appropriate radiocarbon age. If an "\*" is attached to this date, it means the  $^{13}\text{C}/^{12}\text{C}$  was estimated rather than measured (The ratio is an option for radiometric analysis, but included on all AMS analyses.) Ages are reported with the units "BP" (Before Present). "Present" is defined as AD 1950 for the purposes of radiocarbon dating.

Results for samples containing more  $^{14}\text{C}$  than the modern reference standard are reported as "percent modern carbon" (pMC). These results indicate the material was respiring carbon after the advent of thermo-nuclear weapons testing and is less than ~ 50 years old.

Applicable calendar calibrations are included for materials between about 100 and 19,000 BP. If calibrations are not included with a report, those results were too young, too old, or inappropriate for calibration. Please read the enclosed page discussing calibration.

## PRETREATMENT GLOSSARY

### Standard Pretreatment Protocols at Beta Analytic

Unless otherwise requested by a submitter or discussed in a final date report, the following procedures apply to pretreatment of samples submitted for analysis. This glossary defines the pretreatment methods applied to each result listed on the date report form (e.g. you will see the designation "acid/alkali/acid" listed along with the result for a charcoal sample receiving such pretreatment).

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date, which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. Effects such as the old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems. If you suspect your sample requires special pretreatment considerations be sure to tell the laboratory prior to analysis.

#### "acid/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCl acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles")

Typically applied to: charcoal, wood, some peats, some sediments, and textiles "acid/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction, which precipitates, is rinsed and dried prior to combustion.

#### "acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is bathed in (sodium chlorite)  $\text{NaClO}_2$  under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods that are either very old or highly contaminated.

Applied to: wood

#### "acid washes"

Surface area was increased as much as possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCl) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample was not be subjected to alkali washes to ensure the absence of secondary organic acids for intentional reasons. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

FROM: Darden Hood, Director (mailto:<mailto:dhood@radiocarbon.com>)  
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

March 14, 2006

Dr. Tricia Gabany-Guerrero  
Mexecri, Inc.  
95 Fitchville Road  
Dozrah, CT 06334  
USA

RE: Radiocarbon Dating Results For Samples ALB033575060 L8CLIFF, T2-10-05CALDALBERCA, T2-2-05CALDALBERCA, MAR-C-Y1-90-05, MAR-C-NW-50-05, JF-C5-54-7M-05

Dear Dr. Gabany-Guerrero:

Enclosed are the radiocarbon dating results for six samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of analyses was previously invoiced. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

*Darden Hood*

269  
221  
Cal. for B&W?

Dr. Tricia Gabany-Guerrero

Report Date: 3/14/2006

Mexecri, Inc.

Material Received: 2/2/2006

Sample Data	Measured Radiocarbon Age	13C/ 12C Ratio	Conventional Radiocarbon Age(*)
Beta - 213893 SAMPLE : ALB033575060 L8CLIFF ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 7030 to 6860 (Cal BP 8980 to 8820) AND Cal BC 6850 to 6490 (Cal BP 8800 to 8440)	7640 +/- 70 BP	-12.5 o/oo	7840 +/- 70 BP
Beta - 213894 SAMPLE : T2-10-05CALDALBERCA ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 410 to 360 (Cal BP 2360 to 2310) AND Cal BC 290 to 230 (Cal BP 2240 to 2180)	2280 +/- 40 BP	-23.9 o/oo	2300 +/- 40 BP
Beta - 213895 SAMPLE : T2-2-05CALDALBERCA ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1300 to 1420 (Cal BP 650 to 530)	570 +/- 40 BP	-24.2 o/oo	580 +/- 40 BP
Beta - 213896 SAMPLE : MAR-C-Y1-90-05 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1190 to 1290 (Cal BP 760 to 660)	790 +/- 40 BP	-25.6 o/oo	780 +/- 40 BP
Beta - 213897 SAMPLE : MAR-C-NW-50-05 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 770 to 980 (Cal BP 1180 to 970)	1150 +/- 40 BP	-23.8 o/oo	1170 +/- 40 BP

Dr. Tricia Gabany-Guerrero

Report Date: 3/14/2006

Sample Data	Measured Radiocarbon Age	<sup>13</sup> C/ <sup>12</sup> C Ratio	Conventional Radiocarbon Age(*)
Beta - 213898 SAMPLE : JF-C5-54-7M-05 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1440 to 1640 (Cal BP 510 to 310)	370 +/- 40 BP	-24.4 o/oo	380 +/- 40 BP

PARANGARICUITIRO: Marciano and Ambrosio FIELDS Radiocarbon Results - 2005-2006

MARCIANO PIT SAMPLES											
BETA	Received	Due	Submitter No.	Service	Material Pretreatment	Measured Age	$13C/12C$	Conventional Age	ALL RADIOCARBON: TGG 2 Sigma Calibration (click Link to Retrieve Plot)	Report Completed	NOTE
213897	Thursday, February 02, 2006	Thursday, March 16, 2006	MAR-C-NW-50-05	AMS-Standard delivery	(charred material): acid/alkali/acid	1150 +/- 40 BP	-23.8 o/oo	1170 +/- 40 BP	Cal AD 770 to 980 (Cal BP 1180 to 970)	Tuesday, March 14, 2006	NW PIT from Marciano Field
213896	Thursday, February 02, 2006	Thursday, March 16, 2006	MAR-C-Y1-90-05	AMS-Standard delivery	(charred material): acid/alkali/acid	790 +/- 40 BP	-25.6 o/oo	780 +/- 40 BP	Cal AD 1190 to 1290 (Cal BP 760 to 660)	Tuesday, March 14, 2006	Yacata 1 from Marciano Field
238711	12/12/2007		ELMARRMWP12			6190 +/- 40 BP	-24.2 o/oo	6200 +/- 40BP	Cal BC 5290 to 5040 (Cal BP 7240 to 6990)		Ambrosio Stacked Rock Feature 12

FROM Anthony

NEED LATEST SAMPLES from 2008-2009

## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2:lab. mult=1)

Laboratory number: Beta-238711

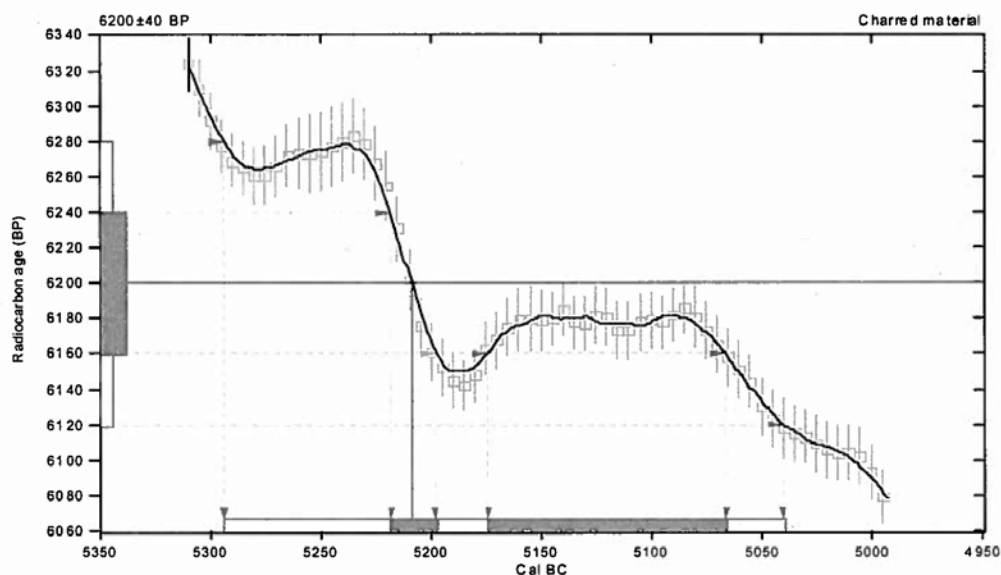
Conventional radiocarbon age: 6200±40 BP

2 Sigma calibrated result: Cal BC 5290 to 5040 (Cal BP 7240 to 6990)  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal BC 5210 (Cal BP 7160)

1 Sigma calibrated results: Cal BC 5220 to 5200 (Cal BP 7170 to 7150) and  
(68% probability) Cal BC 5170 to 5070 (Cal BP 7120 to 7020)



### References:

- Database used*  
INTCAL04  
*Calibration Database*  
INTCAL04 Radiocarbon Age Calibration  
*IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).*
- Mathematics*  
*A Simplified Approach to Calibrating C14 Dates*  
Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.5;lab. mult=1)

Laboratory number: Beta-213893

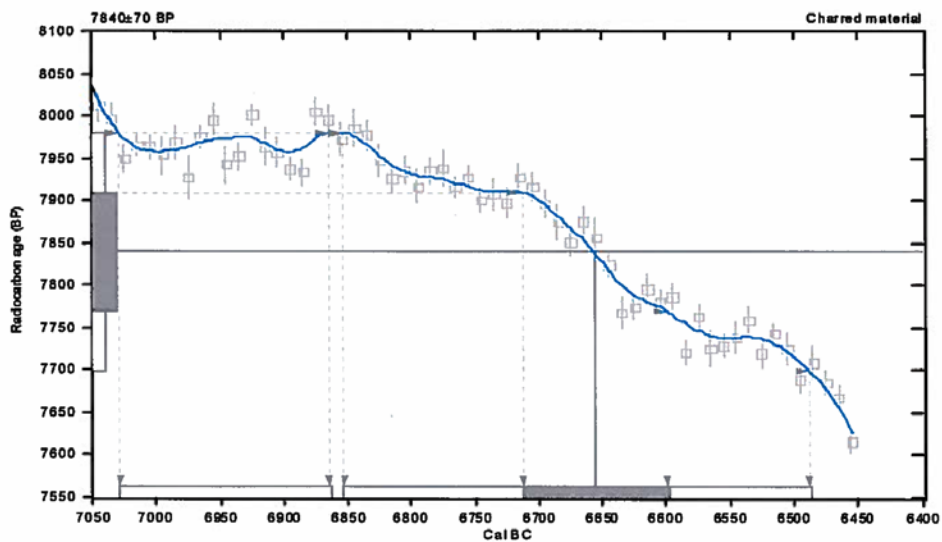
Conventional radiocarbon age: 7840±70 BP

2 Sigma calibrated results: Cal BC 7030 to 6860 (Cal BP 8980 to 8820) and  
Cal BC 6850 to 6490 (Cal BP 8800 to 8440)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal BC 6660 (Cal BP 8610)

1 Sigma calibrated result: Cal BC 6710 to 6600 (Cal BP 8660 to 8550)



### References:

*Database used*

*INTCAL98*

*Calibration Database*

*Editorial Comment*

*Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxi-ix*

*INTCAL98 Radiocarbon Age Calibration*

*Stuiver, M., et al., 1998, Radiocarbon 40(3), p1041-1083*

*Mathematics*

*A Simplified Approach to Calibrating C14 Dates*

*Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322*

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.9;lab. mult=1)

Laboratory number: Beta-213894

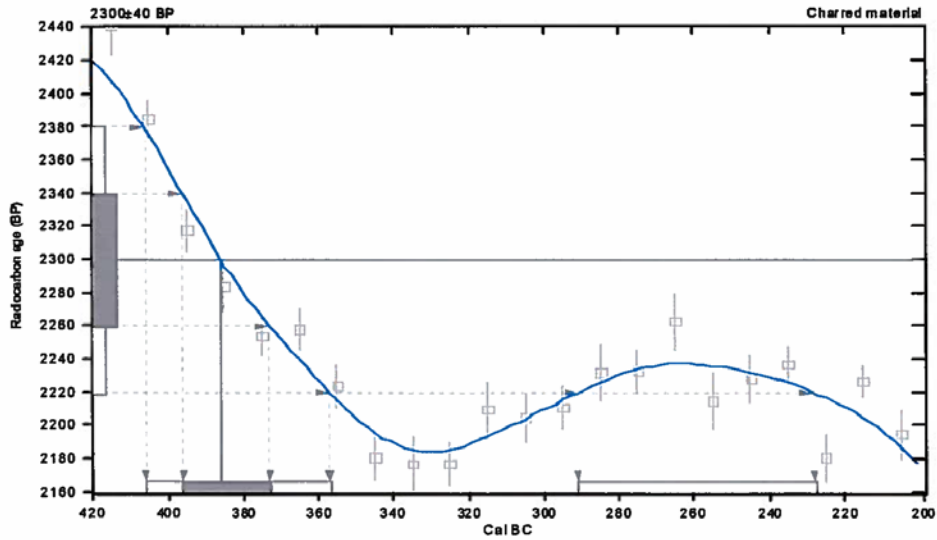
Conventional radiocarbon age: 2300±40 BP

2 Sigma calibrated results: Cal BC 410 to 360 (Cal BP 2360 to 2310) and  
(95% probability) Cal BC 290 to 230 (Cal BP 2240 to 2180)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal BC 390 (Cal BP 2340)

1 Sigma calibrated result: Cal BC 400 to 370 (Cal BP 2350 to 2320)  
(68% probability)



### References:

- Database used  
INTCAL98  
Calibration Database  
Editorial Comment  
Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xii
- INTCAL98 Radiocarbon Age Calibration  
Stuiver, M., et al., 1998, *Radiocarbon* 40(3), p1041-1083
- Mathematics  
A Simplified Approach to Calibrating C14 Dates  
Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2;lab. mult=1)

Laboratory number: Beta-213895

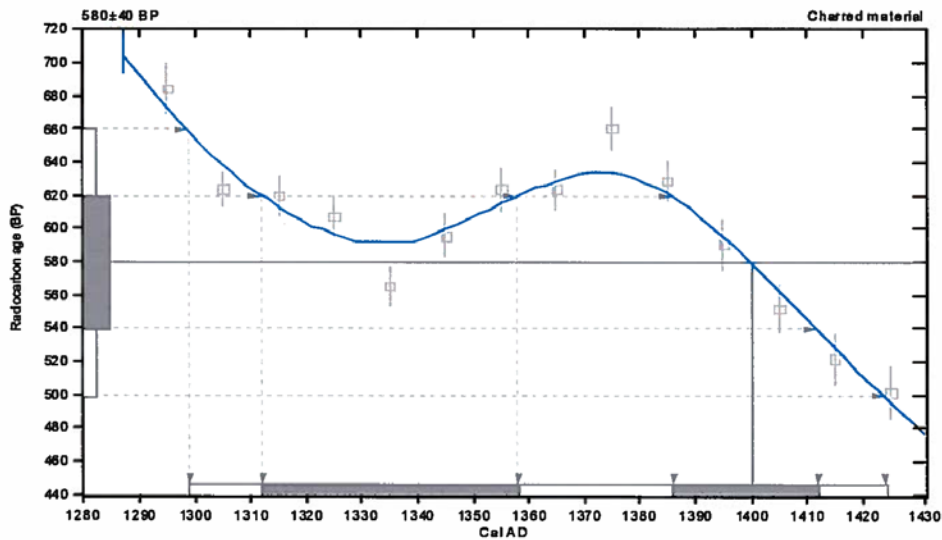
Conventional radiocarbon age:  $580 \pm 40$  BP

2 Sigma calibrated result: Cal AD 1300 to 1420 (Cal BP 650 to 530)  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal AD 1400 (Cal BP 550)

1 Sigma calibrated results: Cal AD 1310 to 1360 (Cal BP 640 to 590) and  
Cal AD 1390 to 1410 (Cal BP 560 to 540)



### References:

- Database used  
INTCAL98  
Calibration Database  
Editorial Comment  
Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xii
- INTCAL98 Radiocarbon Age Calibration  
Stuiver, M., et al., 1998, *Radiocarbon* 40(3), p1041-1083
- Mathematics  
A Simplified Approach to Calibrating C14 Dates  
Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.6;lab. mult=1)

Laboratory number: Beta-213896

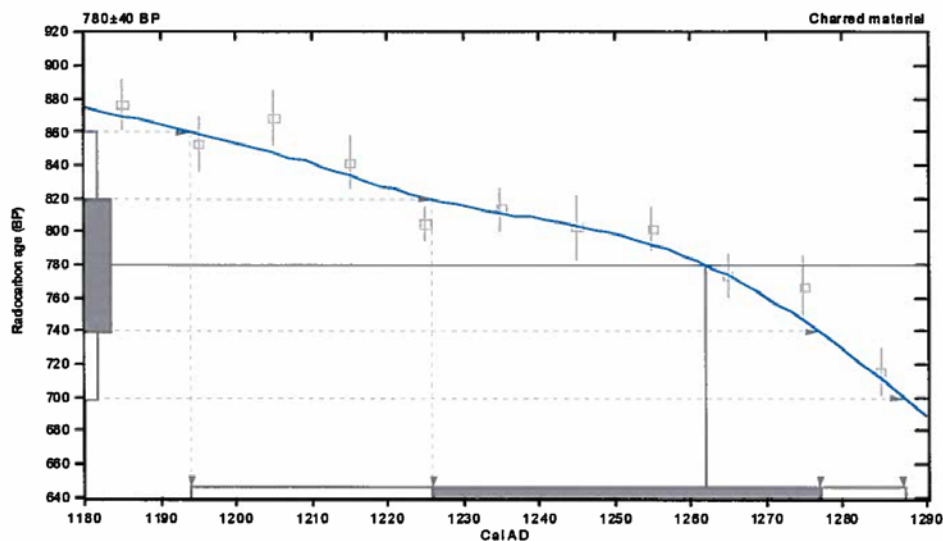
Conventional radiocarbon age:  $780 \pm 40$  BP

2 Sigma calibrated result: Cal AD 1190 to 1290 (Cal BP 760 to 660)  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal AD 1260 (Cal BP 690)

1 Sigma calibrated result: Cal AD 1230 to 1280 (Cal BP 720 to 670)  
(68% probability)



### References:

*Database used*

*INTCAL98*

*Calibration Database*

*Editorial Comment*

*Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxi-xxii*

*INTCAL98 Radiocarbon Age Calibration*

*Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083*

*Mathematics*

*A Simplified Approach to Calibrating C14 Dates*

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.8;lab. mult=1)

Laboratory number: Beta-213897

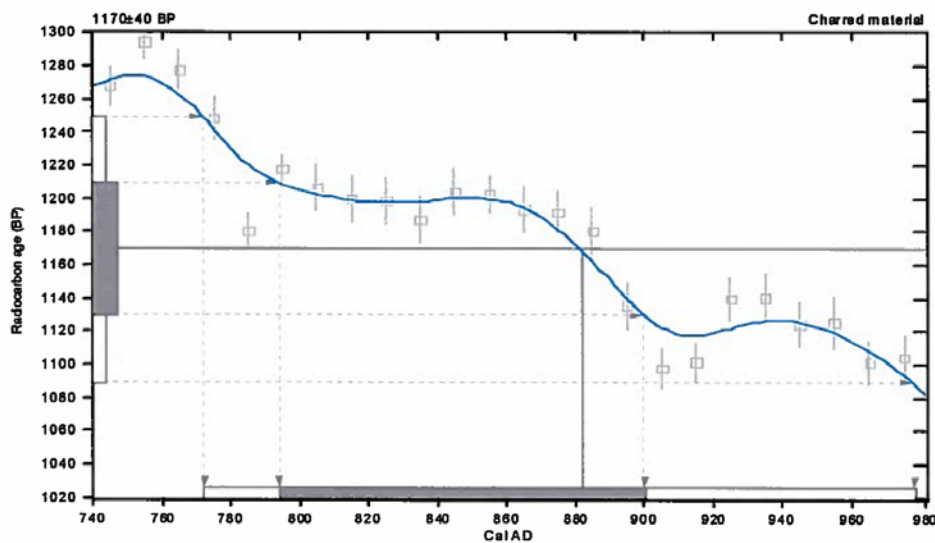
Conventional radiocarbon age: 1170±40 BP

2 Sigma calibrated result: Cal AD 770 to 980 (Cal BP 1180 to 970)  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal AD 880 (Cal BP 1070)

1 Sigma calibrated result: Cal AD 790 to 900 (Cal BP 1160 to 1050)  
(68% probability)



### References:

*Database used*

INTCAL98

*Calibration Database*

*Editorial Comment*

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxi-xii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, *Radiocarbon* 40(3), p1041-1083

*Mathematics*

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## CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.4;lab. mult=1)

Laboratory number: Beta-213898

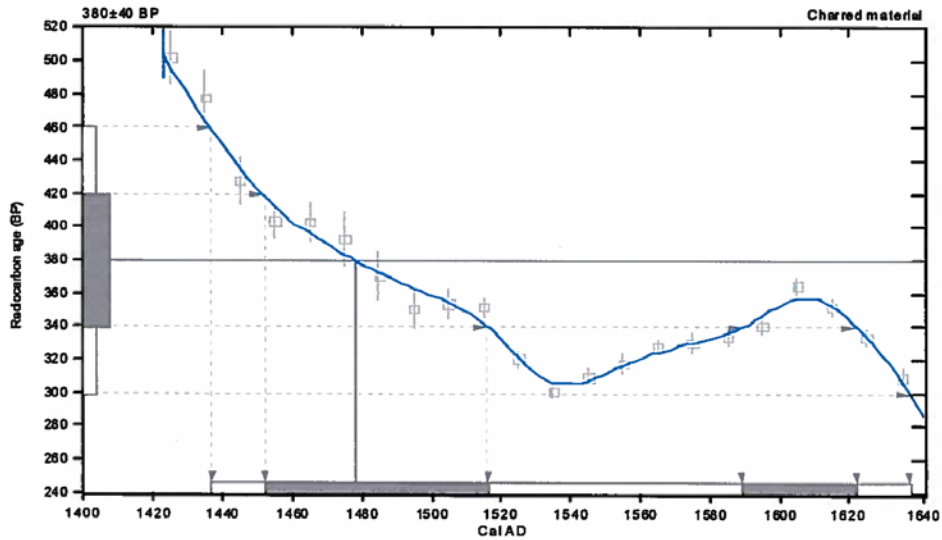
Conventional radiocarbon age: 380±40 BP

2 Sigma calibrated result: Cal AD 1440 to 1640 (Cal BP 510 to 310)  
(95% probability)

Intercept data

Intercept of radiocarbon age  
with calibration curve: Cal AD 1480 (Cal BP 470)

1 Sigma calibrated results: Cal AD 1450 to 1520 (Cal BP 500 to 430) and  
(68% probability) Cal AD 1590 to 1620 (Cal BP 360 to 330)



### References:

- Database used  
INTCAL98  
Calibration Database  
Editorial Comment  
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