



Geochemical characterization of inorganic residues on plaster floors from a Maya palace complex at Actuncan, Belize



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ABSTRACT

This report describes the results of a geochemical analysis using a mild acid extraction and inductively coupled plasma-mass spectroscopy of 198 samples from plaster surfaces at the palace complex at Actuncan, a prehispanic Maya city located in a karst landscape of western Belize. Archeologists working in the Maya region of Central America often refer to many different kinds of building complexes as “palaces” without a clear understanding of how they functioned. Often, the rooms inside these structures are devoid of features and artifacts, making it difficult to infer how they were used. Geochemical characterization of inorganic residues on plaster floors as a means of prospecting for activity areas is therefore critical for studying the function and meaning of ancient Maya palaces. At Actuncan, due to the high degree of preservation of many of the floors, overlying plaster surfaces were able to be sampled, thus informing not only how the buildings were used, but how their uses changed over time. Multivariate quantitative modeling and spatial interpolation of the chemical data demonstrate that a variety of domestic, ritual, and possibly administrative activities took place in the palace complex, a finding that challenges previous assessments of palaces as primarily royal residential compounds.

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1. Introduction

Archeologists working in the Maya region call many different buildings and building complexes “palaces” without a clear understanding of their varied functions. As Harrison (2003: 100) points out, the term “palace” is borrowed from the European lexicon and its use implies their primary function was as aristocratic residences as opposed to religious temples, meeting halls, or storage facilities. However, the real situation was more complex, as Maya palaces were multi-functional spaces where elites lived, the royal court met, and civic and ritual activities took place (Inomata and Houston, 2001). While some large agglutinated structures, such as those found at Tikal or Copán (Harrison and Andrews, 2004), served many functions, other constructions that Mayanists have called palaces are smaller and may have served more specialized functions (Webster and Inomata, 2004).

Sorting out the functions of buildings and the rooms inside them requires an understanding of the location, size, and shape of the complex; the layout and features of its rooms; and artifacts or residues left inside them (Christie, 2003). Palace rooms themselves are often devoid of features, other than benches, and their shape and location within a room block do not offer many clues as to the kinds of activities performed

within them. In addition, the ancient Maya often swept clean civic-ceremonial and domestic spaces. Therefore, chemical residue analysis of floors provides essential data to reconstruct the activities that took place in palaces (Wells et al., 2000).

This report describes the results of geochemical characterization of 198 plaster samples from living surfaces in the palace complex at the ancient Maya settlement of Actuncan, Belize (Fig. 1). We seek to understand the behavioral significance of the deposition and distribution of chemical elements that can be linked through ethnoarcheological and experimental studies to a variety of human activities involving food preparation and consumption among other activities (Barba and Ortiz Butrón, 1992; Barba et al., 1995; Wells and Moreno Cortés, 2010; Wells and Terry, 2007).

Three areas of the palace complex were sampled for geochemical residues (LeCount, 2013). Structure 19 (n = 102) is a range structure, while Structures 21A/21B (n = 39) and 22 (n = 60) are buildings that form a patio attached to the north side of Structure 19 (Fig. 2). Samples derive from sections of plaster floors and date to the Terminal Preclassic, ca. 100 B.C.–A.D. 300 and Late Classic, ca. A.D. 600–780, periods. The objective of this study is to investigate chemical patterns indicating activity loci in each area and to compare patterning between spaces and through time. The greater goal of this effort is to better understand how the palace functioned at Actuncan and the corresponding implications for sociopolitical and economic organization.

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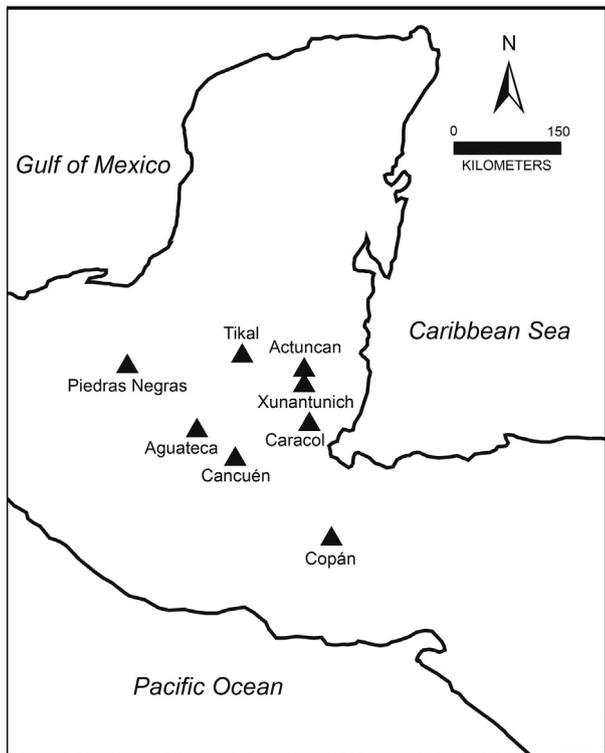


Fig. 1. The location of Actuncan, Belize and other archeological sites mentioned in the text.

2. Geochemical residue analysis

2.1. Sediment chemistry

Recent advances in geochemical characterization of soils and sediments from archeological contexts demonstrate that a broad range of

inorganic chemical residues are preserved as insoluble oxides, sulfides, and carbonates on prepared surfaces at prehispanic settlements in southern Mesoamerica (Anderson et al., 2012; Canuto et al., 2010; Cook et al., 2006; Coronel et al., 2015; Dahlin et al., 2007; Eberl et al., 2012; Fernández et al., 2002; Fulton et al., 2013; Hutson and Terry, 2006; Inomata et al., 2001; Luzzadder-Beach et al., 2011; Parnell et al., 2002; Terry et al., 2004; Wells, 2004; Wells et al., 2007). This research is possible, because different human activities result in the deposition of specific chemical compounds onto activity surfaces. Through processes of cation exchange, adsorption, and complexation, the chemical constituents of activity residues become a permanent part of the archeological record (Wells, 2006; Wells et al., 2013).

Phosphates, in particular, have long been recognized as markers of human settlement and activities involving the deposition of organic matter (Arrhenius, 1931; Holliday and Gartner, 2007). More recently, archeologists have discovered that many other chemical residues, especially metals and trace elements, can be recovered from archeological surfaces and that these residues can be associated with specific activities (Entwistle et al., 2007; Middleton and Price, 1996). Several analytical techniques have been developed for the field (e.g., Eidt, 1985; Terry et al., 2000) and laboratory (e.g., Abrahams et al., 2010; Middleton, 2004) that allow for the extraction of anthropogenic fractions or total digestion of sediments to facilitate chemical characterization. Most recently, portable X-ray fluorescence spectrometry (see Shackley, 2011) has been applied to sediments and plasters in attempts to further enhance the analytical process (Coronel et al., 2014; Johnson, 2014; McCormick and Wells, 2014).

2.2. Plaster surfaces

In the Maya region, plaster floors are ideal surfaces from which to extract chemical residues, since they are often composed of lime-based (calcium carbonate) plaster, a calcareous surfacing that traps and preserves a variety of chemical compounds over very long periods (Barba, 1990, 2007; Hutson and Terry, 2006; Pecci et al., 2010; Wells,

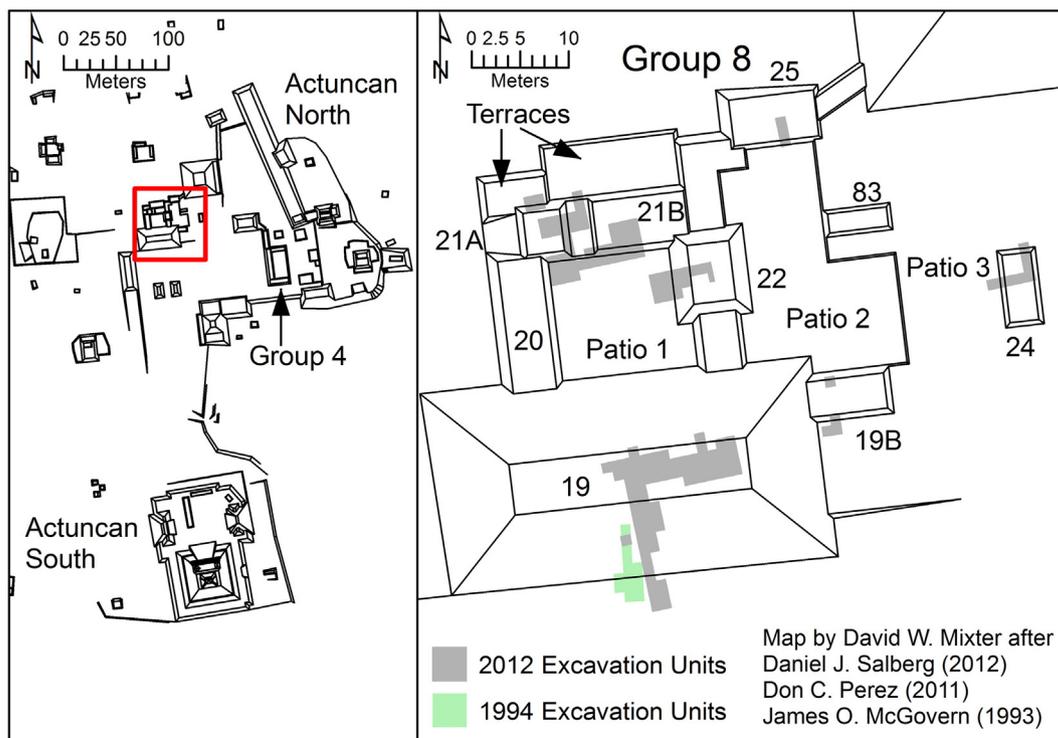


Fig. 2. Plan view map of the palace complex at Actuncan, showing the locations of Structures 19, 21A/21B, and 22. (Map by David W. Mixer.)

2004). Inorganic phosphate and potassium compounds, for example, are retained in these earthen materials by binding with complex aluminum- and iron-containing minerals, such as apatite clays (Albert, 1986). The extremely small size of clay particles (<.002 mm) correlates with small pore sizes between clay platelets, and the relatively high surface tension in these pores can result in mechanical binding of phosphates and other chemicals (Hausenbuiller, 1972: 266–270).

The sediments for the present study derive from magnesium limestone substrates (containing magnetite, calcite, and dolomite), with naturally elevated concentrations of calcium, magnesium, and strontium. The clay minerals are hydrous aluminosilicates produced by the disintegration and chemical decomposition of sedimentary rocks. The three major clay groups in this region of Belize include kaolinites, illites, and montmorillonites, which contribute elevated levels of aluminum and, in the case of illites, potassium, to soils and sediments. In this study, the samples derive from two kinds of surfacings: lime plaster and a type of weathered limestone locally referred to as *sascab*.

Lime plasters consist of a binder (clay, lime, or gypsum), an aggregate (sand or crushed stone), and additives (such as plant ash or volcanic ash) combined in varying proportions according to their intended application (see Abrams et al., 2012; Hansen, 2000; Littmann, 1962; McVey, 1998; Russell and Dahlin, 2007; Villaseñor Lambert, 2010). Lime is produced from the calcination of limestone (calcium carbonate, CaCO₂). When heated to approximately 800–900 °C, the calcium carbonate decomposes into carbon dioxide and quicklime (finely powdered calcium oxide). With the addition of water, a process called “slaking” or hydrating, the mixture yields a product known as slaked lime calcium hydroxide. Exposure to the air allows the evaporation of water and adsorption of carbon dioxide, eventually hardening the plaster to a solid mass.

Sascab (calcium carbonate in an unburnt state) was sometimes used instead of lime plaster on occupation surfaces. Referred to in historical accounts as “white earth” (Wells and Mihok, 2010: 19), *sascab* is the product of the natural weathering of limestone and is found in pockets underneath the caprock. Archeological research has revealed that *sascab* was employed in the construction of buildings, as a protective layer for some patio and plaza floors (e.g., Barba, 2007; Wells, 2004), and especially for roads (*sacbe*) throughout the Maya region.

2.3. Expectations for Maya palaces

In the Maya region, geochemical prospection has seldom been employed to reconstruct activities in and around palaces. However, three recent projects provide insights into our research at Actuncan and help to frame testable implications for the present study. First, Wells et al. (2000) investigated chemical patterning on patios and interior floors of an elite residential complex on the eastern edge of the South Group Plaza at the Late Classic city of Piedras Negras in north-western Guatemala. Using Mehlich II and DTPA extraction with ICP-AES, they identified areas of food consumption on terraces outside of rooms based on significantly higher levels of phosphorus and potassium compared to off-site (background) samples (Wells et al., 2000: 456). Notably, these patterns were absent around the entryways to ancestor shrines and temple substructures in the complex, suggesting that these areas were kept clean of refuse (Wells et al., 2000: 457–458). By matching the chemical record of sediments with the locations of artifacts, they were able to associate various types of craft production (chert and obsidian tools, iron pyrite mirrors, and possibly textiles) with heavy metals, such as iron and manganese (Wells et al., 2000: 456). Finally, the combination and concentrations of iron, mercury, and copper recovered from the bases of exterior building walls suggest the possibility that building facades were once painted (Wells et al., 2000: 456–457).

The second project, carried out by Inomata et al. (2001; see also Terry et al. 2004), explored elite palace activities at the rapidly-abandoned Late Classic city of Aguateca in northern Guatemala. The

team sampled interior floor spaces throughout the palace group and analyzed sediments using the same extraction and characterization procedures as Wells and colleagues. Inomata's group found evidence for high levels of iron on the floors, suggesting that the surfaces were painted red with hematite (iron [III] oxide, Fe₂O₃; Inomata et al., 2001: 298). Low levels of phosphate undifferentiated by room suggest that food was prepared and possibly consumed elsewhere (Inomata et al., 2001: 300). Adjacent to the palace group, the team also investigated a number of elite residences (Inomata et al., 2001: 1243–1244). The central room of one building, argued by Inomata and colleagues to be a courtly room for political gatherings, was chemically undifferentiated from background samples. The northern room contained utilitarian ceramics, very high phosphorus concentrations, and low levels (relative to background samples) of metals, suggesting food storage or preparation activities. The southern room contained mosaic pieces of pyrite mirrors, low phosphorus, and high levels of metals (especially Fe, Cu, Mn, Pb, and Zn), indicating craft production.

Finally, Cook et al. (2006) examined soil chemical patterns around residences and workshops near the palace group at the Classic Maya city of Cancuén in central Guatemala. They used nitric acid with microwave digestion along with ICP-MS for characterization of heavy metals and rare earth elements. They found mercury enrichment on several occupational surfaces, indicating the presence of cinnabar (red mercury [II] sulfide, HgS). While the highest levels of mercury were found associated with special deposits, such as human burials and ritual caches, broader-scale enrichment across the floors suggests that mercury was also involved in other activities, possibly including craft production (Cook et al., 2006: 636–637).

Given the findings from these prior studies, at Actuncan we might expect to find palace rooms separated by function, with some rooms (e.g., the central room, as at Aguateca) reserved for administrative and political activities and other rooms (such as the ancillary spaces and buildings at Piedras Negras and Cancuén) used for a range of domestic activities, including food preparation and craft manufacture. Moreover these and other studies (Colomban et al., 2010; Holliday and Gartner, 2007; Vandenabeele et al., 2005) demonstrate that activity areas can be identified based on the combinations and concentrations of different extractable chemical elements associated with specific types of deposits on floors, specifically: organic matter (K and P), plant ash (Na, Mg, Ca, K, and P), and mineral pigments (Ti, Fe, Cu, Zn, and Hg). Since some of the surfaces represent lime plaster floors, the possibility exists that plant ash or other organics added to the plaster during the production process may commingle with anthropogenic residues (see Villaseñor Lambert, 2010). However, based on archeological research (Hauptmann and Yalcin, 2000) and experimental studies (Goodman, 1998), we anticipate that those additives would only be present in very low (e.g., <5 ppm) concentrations and be spread relatively evenly across the surfaces. As such, we do not expect these formation processes to interfere with the detection of activity areas in our study. Finally, it is important to note that the plaster floors derive from karst features that largely represent magnesium limestones containing naturally occurring concentrations of calcium, magnesium, and strontium. Without separate compositional study of local limestones, the sources and extent of spatial variation in these elements cannot be adequately predicted. As such, we suspect that these elements will be difficult to use for identifying activity areas.

3. Actuncan in context

3.1. Environment

The central Belize karst (Cretaceous to Early Tertiary period limestones, dolomites, and marls) covers about 200 km² in an 85 km-long east–west belt located north and west of the Maya Mountains and south of the Belize River Valley. In western Belize, the karst extends 45 km southward toward the Vaca Plateau and the Chiquibul River. From San Ignacio eastward, the karst is about 25 km wide. Elevations

Table 1
Summary statistics (mg kg⁻¹) for extractable chemical elements characterized by ICP-MS.

Floor	Period*	n	Na	K	Mg	Ca	Sr	Ba	Ti	V	Cr	Mn
Blue	LC	64	14.4386	2.6775	66.1288	13,530.4888	3.1131	1.8894	.0248	.1439	.0140	3.0485
			(3.8153)	(1.0866)	(66.4210)	(2637.7835)	(.3577)	(.4294)	(.0212)	(.0164)	(.0092)	(.5676)
Purple	EC/TP	15	14.0060	5.0531	41.4676	10,922.2012	2.6512	2.1550	.0351	.1384	.0133	2.3352
			(2.4891)	(1.9521)	(8.7568)	(730.3373)	(.4767)	(.2291)	(.0225)	(.0125)	(.0097)	(.7036)
Sac	TP	8	15.0064	4.7459	40.2023	11,341.2477	2.9089	2.4516	.0109	.1459	.0097	3.3039
			(1.2004)	(.6256)	(6.3884)	(606.1744)	(.4125)	(.2392)	(.0040)	(.0080)	(.0027)	(.6003)
Gray	TP	8	18.1158	10.5180	73.4038	15,554.0411	2.9364	2.3089	.0517	.1412	.0204	3.8112
			(.9315)	(5.3817)	(14.5118)	(885.4377)	(.5153)	(.3895)	(.0357)	(.0154)	(.0110)	(1.9852)
Tan	TP	4	14.7848	13.4666	41.3405	10,800.7023	3.2479	2.7446	.0339	.1458	.0112	3.2199
			(2.5698)	(6.3530)	(6.1614)	(1182.3848)	(.3164)	(.2826)	(.0324)	(.0059)	(.0084)	(.7587)
Chive	LC	8	17.3306	3.1661	49.4000	8297.5194	2.6652	2.0696	.0406	.1759	.0251	2.9441
			(.8475)	(.4851)	(4.8426)	(483.2010)	(.2969)	(.1508)	(.0111)	(.0120)	(.0033)	(.5584)
Manioc	LC	8	15.1925	2.5699	46.6254	8317.8358	2.5922	1.9473	.0323	.1841	.0129	2.4540
			(2.8571)	(.6033)	(6.6203)	(419.5724)	(.3426)	(.2611)	(.0238)	(.0100)	(.0071)	(.8182)
Onion	LC	8	15.8079	5.3535	52.5530	8378.8589	2.7769	2.2096	.0537	.1902	.0242	2.7866
			(2.4472)	(2.9564)	(21.4967)	(423.4391)	(.2514)	(.1973)	(.0303)	(.0229)	(.0106)	(.4362)
Lettuce	LC	23	15.3389	7.2464	50.4462	8189.7250	3.0991	2.3791	.0512	.1758	.0145	2.9015
			(3.8939)	(5.2463)	(19.6671)	(1737.7252)	(.8609)	(.8000)	(.0448)	(.0390)	(.0093)	(.8340)
Squash	LC	13	13.4963	5.9778	44.5256	11,256.9011	2.7833	1.8863	.0341	.1824	.0203	2.4859
			(3.5478)	(3.9301)	(22.5747)	(4618.4101)	(.4962)	(.3466)	(.0261)	(.0400)	(.0115)	(.5107)
Elmer 1	LC	22	14.0294	3.9722	84.6313	15,837.1098	2.0669	2.2161	.0157	.1147	.0040	2.0017
			(2.1227)	(1.3539)	(72.3820)	(473.8277)	(.4046)	(1.1034)	(.0302)	(.0135)	(.0053)	(.7369)
Elmer 2	LC	17	14.2023	2.9517	40.4382	16,099.9218	2.0103	2.1077	.0076	.1181	.0050	1.5284
			(2.1606)	(.7968)	(12.5820)	(844.8790)	(.4461)	(1.5491)	(.0074)	(.0114)	(.0059)	(.4651)
offsite	unknown	8	2.9692	11.5270	36.8845	4682.4486	1.2360	4.6490	.1122	1.7470	.0880	5.0790
			(1.0450)	(2.2046)	(13.5605)	(3521.7464)	(1.0545)	(1.6164)	(.0260)	(.2320)	(.0165)	(1.3750)
p values (2-tailed) for t-tests comparing archeological sample means with control sample means			<.001	<.001	.212	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Note: values are expressed as: mean (standard deviation).

Period abbreviations: LC (Late Classic), EC/TP (Early Classic or Terminal Preclassic), TP (Terminal Preclassic).

within the karst range from less than 100 m amsl close to the coast to about 500 m amsl on the Vaca Plateau. Actuncan is perched on the edge of a T-3 alluvial terrace overlying karst that edges the Mopan River, which links to the Macal River a few kilometers to the north and drains into the larger Belize River. The Mopan and the Macal dissect the west-central karst into blocks of rugged upland terrain with enclosed depressions, residual hills, and valley systems (Day, 1993). The intervening river valleys have broad alluvial floors with cliffed margins. The plateau, which increases in elevation from about 400 m in the north to roughly 700 m in the south, has relatively uniform summit elevations but with steep (100–150 m) local reliefs (Miller, 1996).

The primary geomorphological features of the region include Quaternary alluvial and colluvial deposits, shallow closed-depressions, and seasonal swamps (Beach et al., 2008). Soils overlying the karst terrain are predominantly calcareous mollisols and vertisols (Beach et al., 2003; King et al., 1992). Soil profiles in the region tend to be less than .5 m thick, although at Actuncan our probes on the T-3 terrace reached depths of 3 m or more to the water table. In the main valleys, alluvial soils are mostly acidic (pH 5.5–6.5) reddish-brown clays and sands. Over the limestone is a species-rich, broadleaved, deciduous seasonal forest, which contains a wide variety of wildlife (Furley and Newey, 1979). During peak rainfall in July, the region receives on average 1500 mm of rain.

3.2. Culture history

Human occupation of the region stretches back to the Preclassic period (ca. 1000 B.C.–A.D. 300). By the Classic period (ca. A.D. 300–1000), the region supported at least 20 civic–ceremonial centers, including the well-known centers of Caracol and Xunantunich. Actuncan is situated 2 km north of Xunantunich, the Late Classic regional capital. The first systematic investigation of Actuncan was conducted by McGovern (2004) in the early 1990s when he mapped the 14-ha site using a total station, documented building sequences by profiling looters' trenches, and tested eight civic structures with excavation. He divided

the site into two sections: Actuncan South and Actuncan North (the focus of the present study). Actuncan South is dominated by a Preclassic temple complex rising 28 m above Plaza A. It is connected to Actuncan North by a wide causeway that opens into Plaza C, a large formal space containing a ball court, range structures, and pyramids. Smaller plazas with civic monuments and elite residential compounds are located on the eastern periphery of Plaza C, and a commoner settlement is situated to the north of Plaza H.

The goal of the current Actuncan Archeological Project is to examine the changing strategies of leadership over the site's 2000 years of occupation from the perspective of households, including that of the rulers. To date, the project has excavated all major domestic structures including six commoner patio-focused groups, three elite residences, and the palace complex that is the focus of this study. In 2012, excavations focused on the centrally located range structure, Structure 19, and the ancillary constructions attached to the northern side of this building, which collectively form Actuncan's only palace complex, known as Group 8. Reconstructions of residential layouts, as well as household developments, are based on deep vertical excavations into each residential structure along with horizontal excavations across domestic floors.

Based on both civic and residential construction sequences, we suggest that Actuncan experienced multiple episodes of growth and diminution suggestive of shifts in regional power through time. Most households were founded in the Terminal Preclassic period, when an earlier Middle to Late Preclassic (ca. 1000–400 B.C.) settlement was buried and much of the civic core was renovated as a royal center. Sometime in the Early Classic period (ca. A.D. 300–600), authority shifted to nearby communities, first to Buenavista del Cayo and later, to Xunantunich. During this hiatus in power, Structure 19 fell into disrepair only to be renovated to form Group 8 when Xunantunich became the regional capital in the Late Classic (ca. A.D. 600–780). In the Terminal Classic period (ca. A.D. 780–1000), Xunantunich, along with much of the Mopan Valley hinterland, experienced demographic decline and eventual abandonment, sparking a political resurgence at Actuncan (LeCount and Yaeger, 2010: 365; Mixter et al., 2014). Population decline

Fe	Co	Ni	Cu	Zn	Y	Hg	U	Al	Pb	P
15.1016	.0364	.6137	.1222	.3975	.0060	.0013	.0007	1.1141	.0020	3.2341
(5.2866)	(.0047)	(.0735)	(.0756)	(.1586)	(.0086)	(.0024)	(.0005)	(1.6557)	(.0040)	(2.9700)
18.1702	.0327	.5030	.1793	.3993	.0270	.0007	.0014	2.5281	.0102	3.6690
(3.0527)	(.0038)	(.0281)	(.0949)	(.1014)	(.0236)	(.0005)	(.0016)	(1.8283)	(.0100)	(1.7705)
21.9397	.0285	.5613	.1275	.3082	.0016	.0008	.0074	.6794	.0003	.8885
(2.3912)	(.0034)	(.0233)	(.0183)	(.0347)	(.0010)	(.0006)	(.0045)	(.2095)	(.0002)	(.5969)
15.6968	.0324	.6046	.2469	.5781	.0428	.0007	.0028	2.7828	.0106	7.5894
(.9430)	(.0021)	(.0505)	(.1009)	(.2387)	(.0500)	(.0006)	(.0014)	(2.8179)	(.0174)	(6.3850)
20.3706	.0324	.5697	.1203	.2457	.0194	.0006	.0027	1.5896	.0050	4.1358
(4.4906)	(.0014)	(.0233)	(.0903)	(.1974)	(.0336)	(.0006)	(.0018)	(2.0941)	(.0093)	(4.3617)
24.9232	.0394	.7214	.2319	.6141	.0564	.0002	.0008	11.8722	.0238	5.8433
(1.9558)	(.0036)	(.0661)	(.0265)	(.0501)	(.0120)	(.0002)	(.0001)	(3.6785)	(.0063)	(1.6422)
23.2308	.0396	.7956	.1606	.4411	.0125	.0003	.0004	1.7569	.0071	4.8800
(6.4333)	(.0042)	(.1228)	(.0689)	(.1497)	(.0166)	(.0001)	(.0003)	(2.1048)	(.0085)	(3.9637)
25.7179	.0421	.8029	.2648	.5619	.0428	.0007	.0012	5.5313	.0150	8.1549
(5.4953)	(.0041)	(.1129)	(.1000)	(.1549)	(.0278)	(.0008)	(.0007)	(3.1390)	(.0088)	(4.8262)
25.2324	.0409	.8014	.1417	.4104	.0232	.0003	.0005	4.9136	.0120	7.6102
(7.7573)	(.0093)	(.1905)	(.0722)	(.1975)	(.0289)	(.0002)	(.0004)	(6.1584)	(.0129)	(7.1538)
16.2944	.0378	.6945	.1462	.4591	.0226	.0016	.0005	4.2554	.0084	6.1681
(6.7142)	(.0078)	(.1691)	(.0738)	(.1120)	(.0232)	(.0027)	(.0002)	(4.5320)	(.0079)	(5.6757)
13.8492	.0245	.4261	.1316	.3010	.0100	.0008	.0008	2.0771	.0099	11.7339
(3.7346)	(.0025)	(.0431)	(.0357)	(.0577)	(.0138)	(.0005)	(.0005)	(2.9597)	(.0111)	(15.2758)
15.8035	.0237	.4436	.1564	.3040	.0189	.0006	.0020	.8087	.0123	2.7885
(4.6798)	(.0027)	(.0406)	(.0639)	(.0660)	(.0441)	(.0006)	(.0021)	(1.1997)	(.0115)	(2.1050)
14.0333	.0429	.4751	.1588	.6620	.6875	.0000	.0069	44.8840	.1872	3.173
(9.9323)	(.0252)	(.1057)	(.0613)	(.1082)	(.1580)	(.0000)	(.0030)	(24.4148)	(.0566)	(.3632)
.036	.018	.002	.764	<.001	<.001	.096	<.001	<.001	<.001	.015

does not appear to have occurred at the site until later, during the Post-classic period (ca. A.D. 1000–1500).

Beginning in the 1880s, the region surrounding Actuncan was occupied by subsistence farms (Leslie, 1987). Completion of the major highways in the 1950s encouraged timber extraction in the region and population growth. Residential and agricultural development in the region increased slowly from the 1960s to the present. Today, the primary ruins of Actuncan are located on a private farm intermixed with cattle pasture. Portions of the site are periodically under cultivation, including the area around the main palace complex. Most recently, much of the site including the palace complex was planted with grass nutritionally beneficial to cattle. There is evidence of possible looting on Structure 22, but these activities do not appear to have disturbed the buried occupational surfaces under investigation.

4. Sampling design and analytical methods

4.1. Field sampling

To investigate activities that took place within the palace complex, we collected point samples across all exposed occupation surfaces, following protocols described by Barba (2007) and Wells (2010). Overall, 198 samples were taken at regular .5 m intervals across floor surfaces using a staggered lattice design (see Wells, 2010: 213–214), unless otherwise interrupted by interior walls. Additional opportunistic samples were taken when warranted by the excavation, for example, when a discolored patch was encountered on a floor. In addition, we took eight background (“control”) samples from a range of landforms and depositional contexts within approximately 2 km from Actuncan. These samples were selected from subsurface horizons at least .25 m below current ground surface in undisturbed areas. Both sets of samples (archaeological and control) were taken with a clean trowel, placed directly into sterilized Whirlpak bags for storage, and later transported to the University of South Florida for analysis.

4.2. Laboratory analysis

For this study, a ca. 1.00 g portion was taken from each sample, pulverized with a Coors porcelain mortar, mixed with 10 ml of .60-molar hydrochloric acid (trace metal grade) with .16-molar nitric acid (trace metal grade) in a phosphate-free polyethylene scintillation vial, and shaken vigorously on an electronic shaker at 220 rpm for 30 min. We decided to use a mild acid extraction (following Lewis et al., 1993) instead of total digestion of the sample, because the mineral constituents of the plaster from a digestion would overwhelm the anthropogenic contributions (see Middleton, 2004). For each sample, the solution was filtered using Whatman ashless (.007%) filter paper and decanted into clean polyethylene vials. The extracts were then diluted with ultrapure deionized water (type I reagent grade 18 Megaohm*cm-1 resistance) to bring the concentrations of the elements of interest into the optimal measurement range of the instrument. All samples were analyzed using a Perkin Elmer Elan II DRC quadrupole inductively coupled plasma-mass spectrometer (detection limits from 0.1 ppt [0.1 ng/L] to 1 ppb [μg/L] for most elements) at the Center for Geochemical Analysis at the University of South Florida. For calibration, known solution standards containing the elements of interest in concentrations bracketing the expected concentrations of the sample were processed during the analysis.

The calibrated concentrations of 21 elements were determined: sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), yttrium (Y), mercury (Hg), uranium (U), aluminum (Al), lead (Pb), and phosphorus (P). The results are reported in parts per million (ppm), or mg element/kg matrix (mg kg⁻¹). Calcium is not included in the discussion that follows, because the samples derive from limestone (calcium carbonate, CaCO₃) plaster surfaces; as a result, it is impossible to differentiate anthropogenic impacts from natural formation processes. In addition, we do not discuss V, Cr, Co, Y, and U, since their concentrations were generally very low and their behavioral significance has not yet been established.

5. Results

A total of 198 samples were analyzed for this study, each deriving from a unique provenience at Actuncan's palace complex. The data show $\leq 5\%$ variation on the NIST CRM (U.S. National Institute of Standards and Technology Certified Reference Material) for all standards and samples (including replicates), and $\leq 5\%$ error on internal quality control (blanks). For the analyses discussed in this section, we converted ppm to base-10 logarithms for comparability, since natural abundances of elements tend not to have normal distributions but to be positively skewed and log-normally distributed (Burton and Simon, 1993: 48). Summary statistics (mg kg^{-1}) for the 21 elements appear in Table 1. As indicated in the table, the mean for each element in the archeological samples is statistically significantly different from that in the control samples (where $p < .05$ in pairwise comparisons), except for Mg ($p = .212$), Cu ($p = .764$), and Hg ($p = .096$).

5.1. Structure 19 (range structure)

Excavations at Structure 19 encountered three phases of construction, but the project did not reach culturally sterile soil. Here we describe the last version of the building, Structure 19-1st, and the terminal rooms on the summit, but also present limited data on 19-2nd and 19-3rd, which were found through a deep sounding excavated through the floor of the central room of the summit architecture.

The eastern half of Structure 19-1st was cleared, exposing three rooms (Fig. 3). Because the Maya often built their room blocks symmetrically, we assume that there are two additional rooms to the west of the centrally placed Room 3. Structure 19-1st was occupied over many hundreds of years. It was initially built in the Terminal Preclassic period, but renovated repeatedly during the Late Classic period. Room 1, on the eastern end of the summit structure, was a small room with a bench. Its terminal floor (called "Blue") was in good condition, located only about .35 m below the current ground surface and presented no evidence of intentional filling or disturbances of any kind. To the west of Room 1 is Room 2, which includes a bench that is preserved in the west half of the room, but destroyed, likely by a fallen tree, in the east half. Blue Floor extended into Room 2, but was resurfaced sometime later in the Late Classic period. We call this resurfacing "White" Floor. Room 3 is located on the central axis of the structure. A long bench extends across the entire back of the room, leaving a .60 m deep floor space. Before the structure's abandonment, both Rooms 2 and 3 were filled in a similar fashion, preserving the plaster surfaces on both the bench and the floor of Room 3.

Below Structure 19-1st are two earlier versions of the range structure. These phases were investigated by excavating down 4.70 m through the central staircases and the floor of Room 3. The surface of 19-2nd is represented by a plaster floor ("Purple") located under 2.30 m of fill below Room 3 that had three areas of burning, but with no artifact concentrations. A construction floor ("Sac") composed of *sascab* was exposed in the fill of 19-2nd. The plaster floor ("Gray") of Structure 19-3rd was encountered at about 2.65 m below the chert cobble fill of 19-2nd. The surface was a fairly substantial plaster floor that replaced an eroded and slumped floor ("Tan") about .12 m below. A charcoal sample from Tan Floor yielded a radiocarbon date of cal. 20 A.D. 130–317 (NOSAMS-99777), and ceramics recovered from the fills of Structures 19-2nd and 19-3rd place their construction and occupation in the Terminal Preclassic period, although Purple Floor may date to the earliest phase of the Early Classic period. In sum, six surfaces from Structure 19 were found, from highest (youngest) to lowest (oldest): White, Blue, Purple, Sac, Gray, and Tan. White and Blue are associated with Str. 19-1st, Purple and Sac with Str. 19-2nd, and Gray and Tan with Str. 19-3rd. We focus our discussion on chemical patterning on the best preserved surfaces with the most exposure: Blue (which includes White Floor in Room 2) (Late Classic), Purple (Early Classic or

Late Terminal Preclassic), Gray (Terminal Preclassic), and Tan (Terminal Preclassic). Sac surface appears to be devoid of anthropogenic residues.

Standardized (base-10 logarithms) distributions of all chemical data for Blue and Purple floors are normal (Kolmogorov–Smirnov test, $p > .01$) and, as expected, the variances are not homogenous between floors (Levene's test, $p \leq .01$). The highest relative variation in the data can be seen with Ti, Hg, Al, and Pb. Aside from Al, which is a natural component of local clays, the high degree of variation in these distributions is likely caused by generally low concentrations of the elements. The distribution of P also varies to a relatively high degree, from .66–21.36 mg kg^{-1} , with coefficients of variation ranging from 48% (on Purple) to 92% (on Blue). The distributions also present a large number of outliers (cases $\geq 1.5 \times$ midspread), especially on Blue, which indicate discrete (non-overlapping) activity areas. Pearson linear coefficients between elements for Blue and Purple indicate correlations between a range of elements, although significant ($p \leq .01$) strong positive correlations ($r \geq .70$) tend to be between the transition metals Fe, Ni, Cu, Zn, and Hg.

Standardized (base-10 logarithms) distributions of all chemical data for Gray and Tan floors are normal (Kolmogorov–Smirnov test, $p > .01$), the variances are homogenous (Levene's test, $p > .01$), and the distributions lack outliers. This suggests that activities on these floors may have been somewhat homogenous and/or overlapping. As with Blue and Purple floors, Ti, Hg, Al, and Pb have the highest degree of relative variation, due to their lower concentrations compared to major elements. Phosphorus varies to a similar extent as Blue and Purple, from 1.06–18.78 mg kg^{-1} . Pearson linear coefficients for Gray and Tan indicate a large number of both strong positive ($r \geq .70$) and strong negative ($r \leq -.70$) correlations, suggesting again that activities on these surfaces likely overlapped. All of these observations, however, must be tempered with the low sample sizes from Gray ($n = 8$) and Tan ($n = 4$), which render conclusions somewhat tenuous regarding these surfaces (although Spearman's rank correlation coefficients, often used with small sample sizes, are consistent with these findings).

Given the observed differences in the use of space between Blue/Purple and Gray/Tan, we performed a one-way analysis of variance (ANOVA) on the chemical data from each floor to examine whether or not Blue and Purple could have supported the same kind of activities compared to Gray and Tan, and equally if Gray and Tan could have shared the same sets of activity residues. The results of the ANOVA and Games–Howell post-hoc test results (showing which floors may be considered similar or different with regard to their activity residues at the $\alpha = .01$ level) appear in Table 2. We chose the Games–Howell test, because it accounts for different sample sizes and variances. The ANOVA results indicate statistically significant differences among all elements ($p < .01$), except Mg ($F = 1.049$; $df = 3, 87$; $p = .375$) and Hg ($F = .506$; $df = 3, 87$; $p = .679$). As noted previously, the concentrations of Mg and Hg do not appear to differ significantly from our background samples. The post-hoc test results show that Blue and Purple are largely similar in terms of the distributions and concentrations of chemical elements associated with human activities (including P but excluding K that may be enriched by local illite clay minerals), and that these floors are distinct from Gray and Tan, which are themselves similar to each other (except for Mg and Ca) in terms of their residue chemistry.

Given the results of the ANOVA, we performed a discriminant function analysis to evaluate the idea that Blue and Purple are chemically linked, that Gray and Tan are chemically linked, and that Blue/Purple and Gray/Tan are distinct from each other. A scatterplot of the results appears in Fig. 4, with the first two canonical discriminant functions accounting for 93% of the variance. As displayed in the axes, Function 1 (explaining 65% of the variance, canonical $R^2 = .83$) is weighted most heavily by Ba (alkaline earth metal) and Fe and Hg (both transition metals), while Function 2 (explaining 28% of the variance, canonical $R^2 = .69$) captures mostly the variation in Na and K (alkali metals), Mg (alkaline earth metal), and Mn (transition metal). These two sets of elements are not geochemically related, and so their deposition



Fig. 3. Photo of the excavation of Structure 19, showing Room 1 (bottom), Room 2 (center), and Room 3 (top). (Photo by Lisa J. LeCount.)

may be anthropogenic. For example, it is well known that the Maya used ochre (hematite or ferric oxide, Fe_2O_3) and cinnabar (mercuric sulfide, HgS) in ritual practices. The presence and differential distribution of Fe and Hg on Blue/Purple may indicate the use of these minerals in activities on these surfaces. In contrast, Na and K are often associated ethnographically with the deposition of wood/plant ash (especially potash), indicating the combustion of organic matter such as through ritual burning events. Thus, it is possible that incense burning, for example, may have characterized an alternative set of activities on Blue/Purple, spatially distinct from the use of cinnabar and ochre. Table 3 displays the classification results for these two functions that correctly classified approximately 97% of the samples according to the floors from which they were excavated. This strongly suggests that the two

Table 2

ANOVA statistically significant Games–Howell post-hoc test results.

Element	Floor ₁	Floor ₂	<i>p</i>
Na	Blue	Purple	<.001
Na	Blue	Gray	<.001
Na	Purple	Gray	<.001
K	Blue	Purple	.002
K	Blue	Gray	.018
Mg	Blue	Purple	.027
Mg	Blue	Tan	.034
Mg	Purple	Gray	.001
Mg	Gray	Tan	.002
Ca	Blue	Purple	<.001
Ca	Blue	Gray	.001
Ca	Blue	Tan	.034
Ca	Gray	Purple	<.001
Ca	Gray	Tan	.004
Sr	Blue	Purple	.012
Ba	Blue	Purple	.010
Ba	Blue	Tan	.017
Mn	Blue	Purple	.009
Fe	Blue	Purple	.025
Fe	Gray	Purple	.044
Co	Blue	Purple	.015
Co	Blue	Gray	.002
Co	Tan	Blue	.011
Ni	Blue	Purple	<.001
Ni	Purple	Tan	.013
Ni	Gray	Purple	.002
Ni	Tan	Blue	.071
Cu	Blue	Gray	.039
Y	Purple	Blue	.019
U	Blue	Gray	.013
Al	Blue	Purple	.023
Pb	Blue	Purple	.027

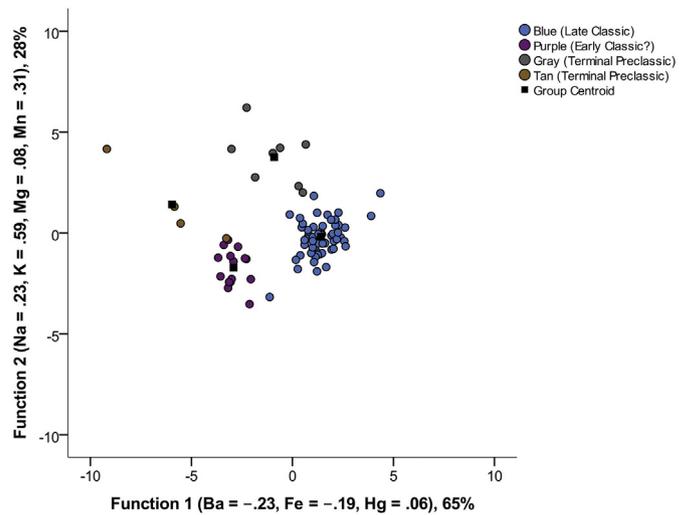


Fig. 4. Plot of functions 1 and 2 from a discriminant function analysis, showing distinctions between Blue, Purple, Gray, and Tan floors from Structure 19 based on different chemical elements. The values associated with each chemical element represent canonical variate correlation coefficients, indicating the substantive nature of each element.

functions we identified are useful discriminants of activity residues in these spaces.

To illustrate these results, Figs. 5 and 6 show boxplots of the main differences, comparing Blue and Gray. Fig. 5 shows that the later Blue Floor has overall lower concentrations (and more contracted ranges) of P ($.66\text{--}9.09\text{ mg kg}^{-1}$) and K ($1.24\text{--}7.91\text{ mg kg}^{-1}$), associated with the deposition of organics, compared to the earlier Gray Floor (P: $1.70\text{--}18.78\text{ mg kg}^{-1}$, K: $4.74\text{--}19.68\text{ mg kg}^{-1}$). The patterns from the Terminal Preclassic floors are consistent with what we would expect to find if these areas were used for food production and consumption, such as through feasting events (LeCount, 2001). Fig. 6 shows that, while Blue and Gray floors share similar concentrations of transition metals (Ti, Ni, Cu, and Zn), associated with mineral-based pigments (e.g., ilmenite [FeTiO_3], millerite [NiS], malachite [$\text{Cu}_2\text{CO}_3(\text{OH})_2$], sphalerite [$(\text{Zn},\text{Fe})\text{S}$]; all deriving from limestone/dolomite host rocks), the distributions for Blue Floor have numerous outliers ($1.5\text{--}3.0 \times$ midspread) and extreme values ($>3.0 \times$ midspread). If these metals derive from mineral-based pigments, as suggested by other studies (Davis-Salazar, 2003; see also Goffer, 2007: 62–75), then these contrasts may indicate that activity patterns on Blue Floor were discrete while those on Gray Floor were more homogenous in character. Moreover, the nature of the mineral pigments themselves suggest that these activities would have involved colors important to the Maya, including black, yellow, and green/blue (Houston et al., 2009).

Finally, we examined the horizontal distribution of the concentrations of different chemical elements to identify original activity locations. Due to the sampling design, we are only able to consider broad distributions for Blue Floor; the sampling loci of the other surfaces are too discontinuous to reasonably interpolate chemical signatures

Table 3

Classification results for discriminant function analysis.

		Blue	Purple	Gray	Tan	Total
Count	Blue	62	1	0	0	63
	Purple	0	15	0	0	15
	Gray	1	0	7	0	8
	Tan	0	1	0	3	4
	%	Blue	98	2	0	0
% (continued)	Purple	0	100	0	0	100
	Gray	13	0	88	0	100
	Tan	0	25	0	75	100

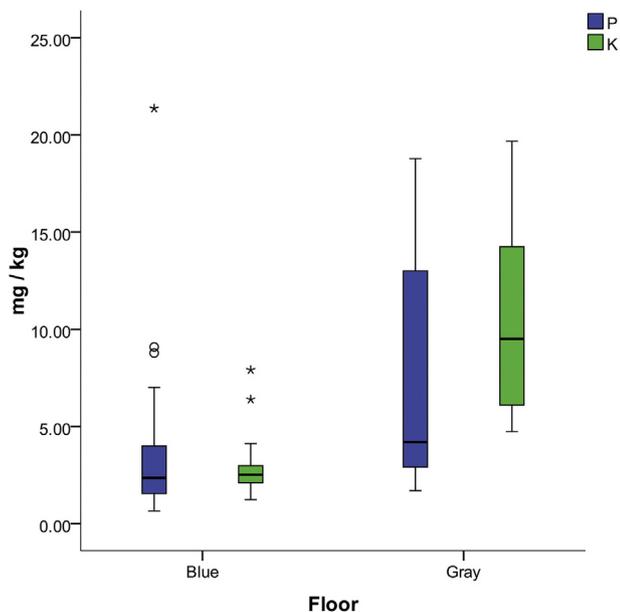


Fig. 5. Side-by-side boxplots comparing P and K concentrations (mg kg^{-1}) between Blue and Gray floors in Structure 19.

compared to Blue Floor. Figs. 7 and 8 show examples of these distributions highlighting P (associated with organics) and Fe (associated with minerals). Darker hues of red indicate higher concentrations of the element. However, higher elemental concentrations do not necessarily reflect the intensity or longevity of the activity responsible for the deposition of that element, since these characteristics are affected by numerous long-term formation processes that differentially impact elemental adsorption (see Bethell and Máté, 1989; Hammond, 1983). The figures show Kriged (interpolated) image maps of extractable amounts of each element in base-10 logarithms for mg kg^{-1} (kriging type = point with zero neighborhood variance and no nugget effect, based on linear semivariogram models; see Cressie, 1990; Kitanidis, 1997).

In these Kriged plots, one can observe the distribution of P (linked to organics, such as in food preparation and/or consumption), where there are generally very low concentrations with few specific points of

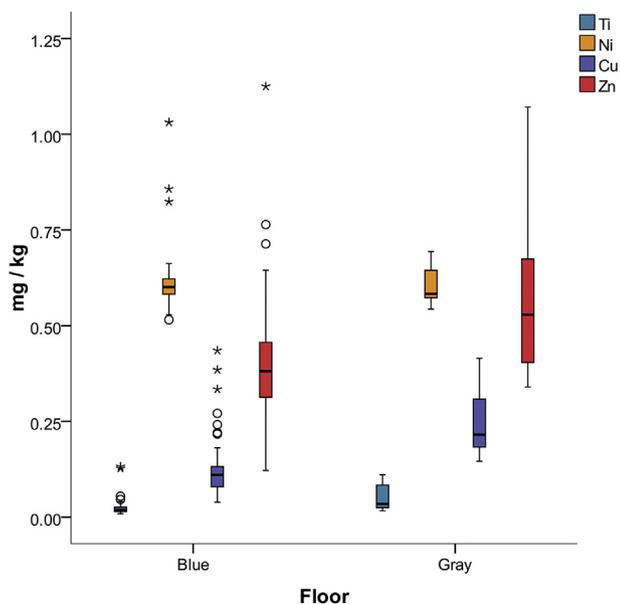


Fig. 6. Side-by-side boxplots comparing Ti, Ni, Cu, and Zn concentrations (mg kg^{-1}) between Blue and Gray floors in Structure 19.

deposition. This pattern is distinct when compared to earlier surfaces, such as Gray Floor, which maintains higher overall levels and discrete concentrations across its surface. Similar patterns are evident with the distribution of K (not pictured), which is often indicative of the deposition of wood/plant ash (CaCO_3 [up to 40%] + K_2CO_3 [about 10%] + PO_4 [$>1\%$] + salts and minerals). In contrast, one can observe the distinct deposition of Fe, often associated with ferric oxide (e.g., ochre). Other elements (not pictured) associated with mineral pigments, including Ti, Cu, Zn, and Hg, have contrasting depositional patterns, as described previously. While sample sizes are not the same between the floors, these observations suggest the possibility that the earlier surfaces were used in different ways: Gray involving food production/processing and consumption (such as in feasting activities) and Blue reserved for mineral-based rituals such as those using ochre and cinnabar.

5.2. Structures 21A/21B and 22 (ancillary buildings)

A small multi-patio group was constructed attached to the north side of Structure 19 during the Samal phase of the Late Classic period (A.D. 600–670). The patio group was occupied throughout the Late Classic, but was abandoned by the Terminal Classic period. Because of the group's multiple patios, it has the appearance of an inchoate agglutinated palace complex similar to those found at larger sites. Research focused on Patio 1, the largest and most formally constructed patio. Low linear mounds that likely supported perishable superstructures line the patio's north and west edges, while a low pyramidal structure dominates the eastern edge.

Structure 21B, the low linear structure lining the north edge of the patio, was built in a single construction phase. Excavations along the structure's southern face uncovered two versions of the patio surface. The earlier patio floor ("Potato," which was not sampled for this study) was constructed in the Early Classic and served as the foundation for Structure 21B. Sometime in the Late Classic, after the construction of Structure 21B, a new patio floor ("Lettuce/Squash") replaced the older, long utilized surface. Patio surfaces were also sampled west of Structure 22, the low pyramid on the group's eastern edge. This structure was originally constructed on "Elmer Floor 2", which was then replaced by "Elmer Floor 1". Both floors date to the Late Classic period. Elmer Floor 1 was likely occupied contemporaneously with Lettuce/Squash Floor located across the patio.

Structure 21A was constructed in the northwest corner of Patio 1. The first two versions of this building, Structures 21A-3rd and 21A-2nd, consisted of an unusual sunken room facing the northwest away from Patio 1. The floors of these structures ("Onion" and "Manioc," respectively) were bounded to the south by a standing masonry wall, and Manioc Floor abutted a stair up to the surface of Structure 21B to the east. Later, a raised platform was constructed over this sunken room rising above the level of Structure 21B. Low terraces were built projecting to the north and west. Samples were collected from "Chive" Floor, which covered the northern terrace. All versions of Structure 21A date to the Late Classic and post-date the construction of Lettuce/Squash Floor.

Here, we focus our discussion on two surfaces, in particular—Lettuce/Squash (Structure 21A/B) and Elmer 1 (Structure 22), which represent the best preserved and most sampled floors in this patio group. Standardized (base-10 logarithms) distributions of the elements on these three surfaces are not normal (Kolmogorov–Smirnov test, $p \leq .01$) and the variances are not homogenous (Levene's test, $p \leq .01$). The data show patterns similar to those seen on both Blue/Purple and Gray/Tan (including especially high variation in Mg [3.80 – $338.27 \text{ mg kg}^{-1}$], K [1.05 – 19.00 mg kg^{-1}], and P [$.18$ – 31.43 mg kg^{-1}]), with a few notable exceptions (e.g., Hg and Pb on Lettuce/Squash) probably due to small sample sizes. Pearson's linear correlation coefficients show strong positive associations between P and many other elements on Elmer 1, including K ($r = .78$), Ba ($r = .87$), Mn ($r = .74$), Ni ($r = .91$), Hg ($r = .73$), Al ($r = .96$), and Pb ($r = .99$). This suggests that P was distributed homogeneously

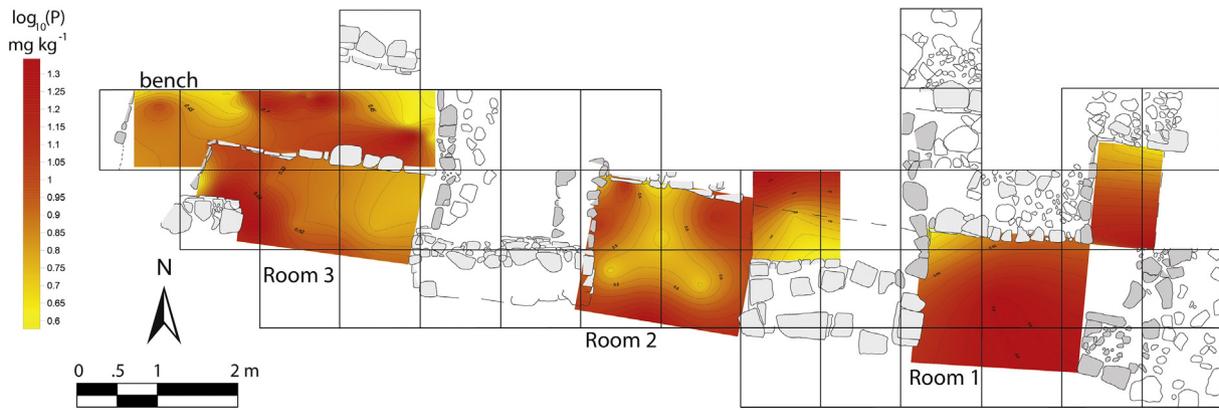


Fig. 7. Kriged image map of the interpolated distribution of P across Blue Floor in Structure 19.

across the patio surface associated with Structure 22 in association with other activities or apart from other activities but in the same spaces as those other activities. A similar observation can be made for Lettuce/Squash, associated with Structure 21B, where $r \geq .70$ between P and K, Ba, Mn, Al, and Pb. This suggests that the patio surfaces near 21A/B and 22 were used for multiple purposes and that activity loci were not necessarily discrete or fixed.

The Kriged interpolations of the chemical elements support the observations regarding the homogeneity of the use of space over time (Figs. 9–10). Since the lower (earlier) surfaces are largely devoid of chemical residues, here we focus on the latest Late Classic surfaces. The northern portion of the patio uncovered by the excavations (represented by Lettuce/Squash Floor) has high concentrations of P and Fe distributed fairly evenly across the surface, while the eastern portion of the patio (represented by Elmer 1 Floor) has lower levels of P and Fe, especially where the space abuts Structure 22. This could suggest that Structures 21A and B may have been involved in more daily residential activities and that Structure 22 may have been reserved for special functions. In contrast to Blue Floor on Structure 19, the distributions of P and Fe in the patio are homogeneously distributed across the patio surface. These patterns appear to be similar to those detected for multi-use residential spaces at other Classic Maya settlements (e.g., Wells et al., 2000).

6. Conclusions

Investigating the history and use of Actuncan's palace complex is important for understanding changing strategies of leadership, because these buildings point to the establishment of a residential palace and hereditary leadership at the site. Palaces can be thought of

quintessentially as buildings established for the purposes of housing hereditary rulers and their burgeoning family and bureaucracy. As such, their construction marks the expansion of leadership roles beyond those tied to the central temple. Originally constructed during Actuncan's Terminal Preclassic height of power, Structure 19 was only converted into a formal palace complex during the Late Classic period. The small size and limited elaboration of ancillary buildings (including Structures 21A/B and 22) suggest that the palace was inhabited by a secondary elite, not a divine king, ruling Actuncan under the aegis of a more powerful ruler elsewhere, possibly at nearby Xunantunich (Mixer et al., 2013).

Our research on the chemical characterization of sediment samples from multiple sets of plaster surfaces at the palace complex reveals the kinds and locations of various activities. The chemical residues identified in the analysis of floors from Structure 19-1st indicate some level of food storage, preparation (including the combustion of wood/plant material), or consumption in all three rooms. The high P levels in Room 1 are focused along the east side of the room near the doorway. In Room 2, the high P levels are concentrated at the back of the room floor at the base of the bench and along the edges of the room where the floors and walls meet. Room 2 is also distinguished from the other rooms as the only location where Fe does not overlap with P. The high degree of preservation of plaster on the bench and floor of Room 3 allowed for identification of elevated P levels in seemingly circumscribed areas on the bench and on the west side of the doorway. These patterns suggest different functions for the rooms. The clearest pattern may be in Room 2, with a high concentration of P at the base of the bench. This seems more likely to indicate storage as opposed to the patterns in Room 3, which may indicate consumption or other activities.

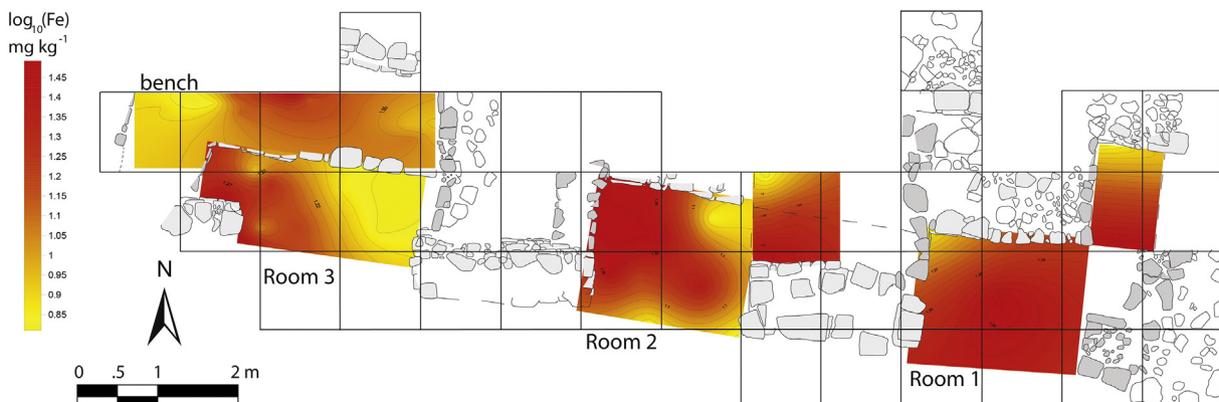


Fig. 8. Kriged image map of the interpolated distribution of Fe across Blue Floor in Structure 19.

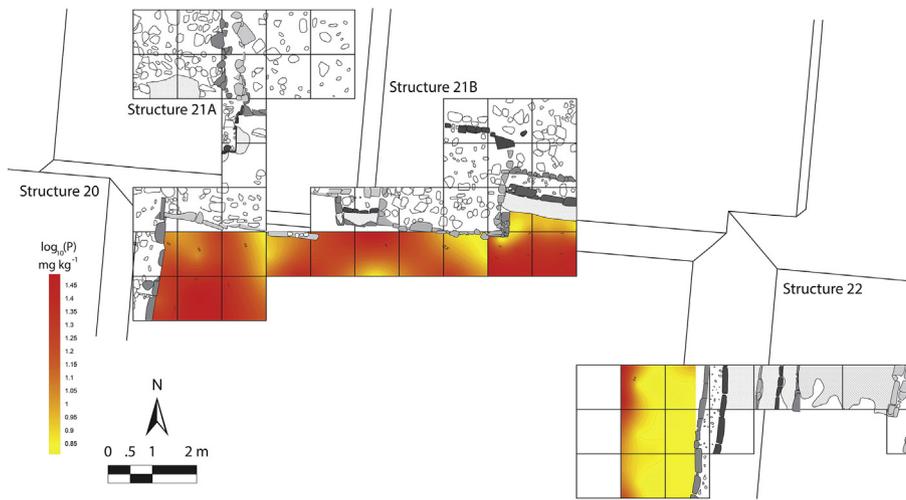


Fig. 9. Kriged image map of the interpolated distribution of P across Lettuce/Squash (north) and Elmer 1 (east) floors in the Group 8 patio.

Overall, these findings contrast with the inferences for other Classic-period palaces in the Maya region, which suggest that the central room in palace room blocks served more political purposes, such as reception areas. At Aguateca, for example, the central room was largely devoid of anthropogenic inputs, while the flanking rooms appear to have been reserved for food preparation or consumption and craft manufacturing (or other diverse activities). Notably, food consumption appears to have been sequestered into one room. At Actuncan, however, there is evidence for the deposition of organics throughout all three rooms, although the way in which food was handled in each room was different. In the central room (Room 3), the large L-shaped bench would have been large enough to accommodate multiple occupants participating in private gatherings that involved food consumption. In painted scenes on Classic-period vases, lords can be seen seated on palace benches surrounded by bowls of tamales, beverages, and other foods indicative of exclusive feasting (LeCount, 2001). Perhaps this kind of formal eating might account for the circumscribed nature of P, as different containers and individuals had designated locations on the bench. In adjacent rooms, food might have been stored (Room 2), prepared, or eaten in the doorway in sight of others (Room 1).

Room 2 (east of the central room) is also distinct from the others in its concentrations of heavy metals, possibly signaling an area for storage of raw materials for ritual paraphernalia or the enactment of ritual performances. Given the location of this room, perched above a large open plaza with a ball court, these performances may have been visible to large groups of people. Inomata et al. (2001: 300) interpret this configuration as “theatrical space” used in political and ritual performances as documented on Classic Maya pictorial pottery (Reents-Budet et al., 1994; Reents-Budet, 2001).

The patio floors in front of the ancillary structures (Structures 21A/B, and 22) are all similar in terms of the ranges and locations of activities. The highest (Late Classic) surfaces all contain anthropogenic signatures of a wide variety of activities, similar in organization to the ancillary buildings and terraces in elite residential spaces investigated at Piedras Negras (Wells et al., 2000) and Cancuén (Cook et al., 2006). Lower (earlier) surfaces are largely devoid of anthropogenic signatures, with a few exceptions. This finding could be related to prior construction practices that erased extant residues, the building’s formation processes, or simply our sampling strategy. Yet, if the absence of residues is behaviorally related to the use of the surfaces in antiquity, then these buildings were either kept clean of refuse or else experienced minimal activities in the

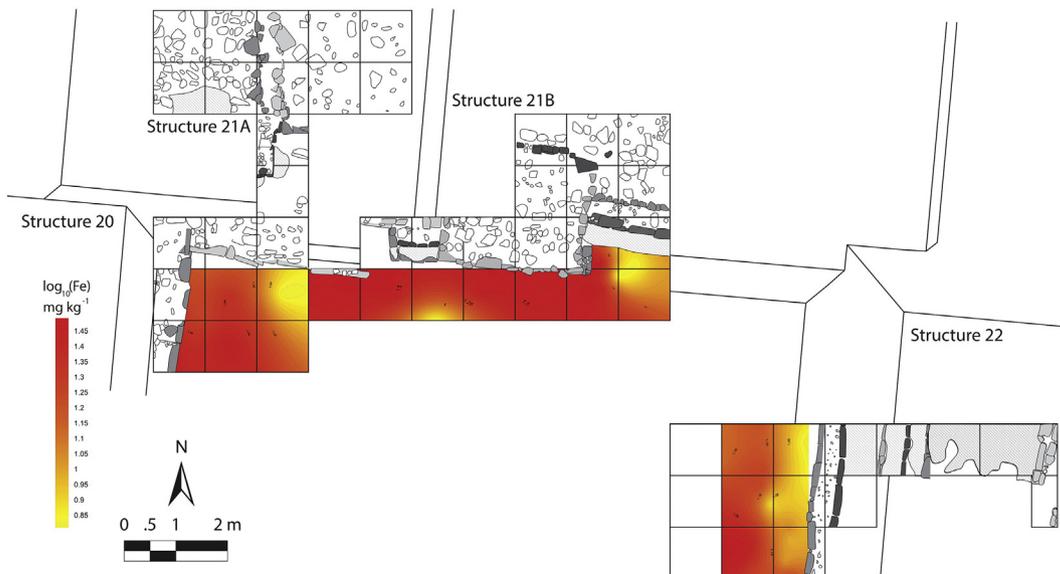


Fig. 10. Kriged image map of the interpolated distribution of Fe across Lettuce/Squash (north) and Elmer 1 (east) floors in the Group 8 patio.

early part of the palace complex's history. If this was the case, then there is evidence that the function of this space likely shifted to a wider range of domestic activities by the Late Classic period. This transition to domestic activities corresponds with the construction and subsequent expansion of the patio groups off the north side of Structure 19, supporting our argument that this construction marked the conversion of Structure 19 from strictly a venue for ritual and polity administration into the focal point of a ruler's palatial residence (Mixer et al., 2013).

Yet the diverse chemical signatures from the palace complex do not support a shift to strictly residential use. Rather, the discrete chemical patterning across each room of Structure 19-1st supports our hypothesis that spaces were reserved for specialized activities, including food consumption, storage and preparation, burning wood/plant material, and ritual performance. Additionally, the lower levels of P directly in front of Structure 22 are similar to patterns found in front of the entrances to temples and shrines at Piedras Negras (Wells et al., 2000). This may indicate that the space was not used for domestic activities, possibly in deference to this eastern building's ritual importance as a shrine.

The broad array of activities at Actuncan's Late Classic palace complex indicates that the construction of agglutinated palaces marks the placement of Maya authority within private residential spaces that contain specific areas for public ritual and administrative activities. This shift in the kinds and locations of palace activities can also be seen in the changing chemical signatures found on Structure 19's floors over time. In contrast to the discrete chemical signatures on the floors of 19-1st, those on Terminal Preclassic floors indicate more widespread food preparation or consumption, evidence that may suggest a shift from inclusive food redistribution by early leaders to exclusive feasting and elaborated ritual by Late Classic rulers.

Future analysis of these data should attempt to evaluate our findings with other methods and analytical instruments (e.g., Middleton et al., 2010) as well as address the complexity of the anthropogenic signatures, such as with multiple regression and principal components analysis (e.g., Chang et al., 2001). Additional evidence that might help to explain the chemical patterning, such as that revealed by microartifact data, now can be meaningfully incorporated into these models, for example, through the use of correspondence analysis or multidimensional scaling (e.g., Fulton, 2015).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.jasrep.2015.12.022>.

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