

Early construction at Nixtun-Ch'ich', Petén, Guatemala: An architectural-footing and -bonding sample

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ABSTRACT

The lowland Maya city of Nixtun-Ch'ich' (Petén, Guatemala) exhibits an atypical gridded layout featuring quadrilateral blocks of architectural construction, established in the Middle Preclassic period (~800–500 BCE). Early levels of some excavated structures revealed unusual dark-colored, sticky sediments used as architectural footings overlying limestone bedrock and as adhesives for binding construction stones. Physical, mineralogical, and soil nutrient (chemical) properties of two samples of this material were analyzed. The samples were found to be highly organic (high %LOI), and composed primarily of smectite clay. They are characterized by low green strength, marked swelling when mixed with water, and corresponding shrinkage on drying, suggesting low load-bearing capacity. Chemical analyses revealed a slightly elevated pH of 7.8 and high levels of six soil nutrients but low phosphorus, likely making the material unsatisfactory for agriculture. We conclude that these sticky organic clays, probably of lacustrine origin, functioned as bonding agents in early architectural construction.

1. Introduction

Recent archaeological fieldwork at the lowland Maya city of Nixtun-Ch'ich' in the lakes district of the Department of El Petén, northern Guatemala, has focused on its unusual early site plan. This long-lived site exhibits a regular grid of north-south and east-west corridors that demarcate quadrilateral blocks or sectors of architectural construction (Fig. 1). Fully gridded site layouts are extremely rare in the Mesoamerican culture area, which comprises Mexico, Guatemala, Belize, and northwestern Honduras.

Culturally, the eastern part of Mesoamerica—the Yucatán Peninsula, including northern Guatemala and Belize—is identified as the Maya lowlands. Geologically, the peninsula is a marine limestone shelf. Petén is an elevated (100–300 m amsl) interior karst plateau composed of porous, interbedded limestone (CaCO₃) and dolomitic limestone (Ca-MgCO₃) interspersed with gypsum (CaSO₄), marl, occasional concentrations of silica (chert), and clays often containing magnetite nodules and ferric lumps. The central Petén lakes occupy an east-west fault line that roughly separates areas of exposed bedrock of Paleocene-Eocene age to the north and Late Cretaceous age in the south

(Hodell et al., 2004). The proportion of major ions in the brackish waters of the lakes permits them to be characterized as bicarbonate (HCO₃⁻¹) and sulfate (SO₄⁻²) systems. Nixtun-Ch'ich' lies on the western shore of large and deep Lake Petén Itzá (area = 100 km², z_{max} = 165 m), a sulfate system with total dissolved solids of 311 mg L⁻¹ (Brenner, 2018).

Excavations at Nixtun-Ch'ich' yielded radiocarbon-dated samples indicating that the site grid was put into place during the Middle Preclassic period, 800–500 cal. BCE (Pugh and Rice, 2017; Rice and Pugh, 2017). Several areas of early construction revealed unusual black (Munsell 10YR 2/1), dark gray (10YR 3/1), or dark brown (10YR 3–4/2–3), sticky, clayey sediments. These appear in three primary contexts: as an architectural footing, sometimes as much as 40 cm thick, underlying construction and overlying limestone bedrock; as a bonder or mortar-like material above, below, and between individual limestone construction stones; and as a “ballast” layer below plaster floors. Similar dark, sticky, clayey materials have been noted in structures at other Middle Preclassic and later sites in Petén.

Two samples of this unusual black material from Nixtun-Ch'ich' were submitted to the Ceramic Technology Laboratory (CTL) at the

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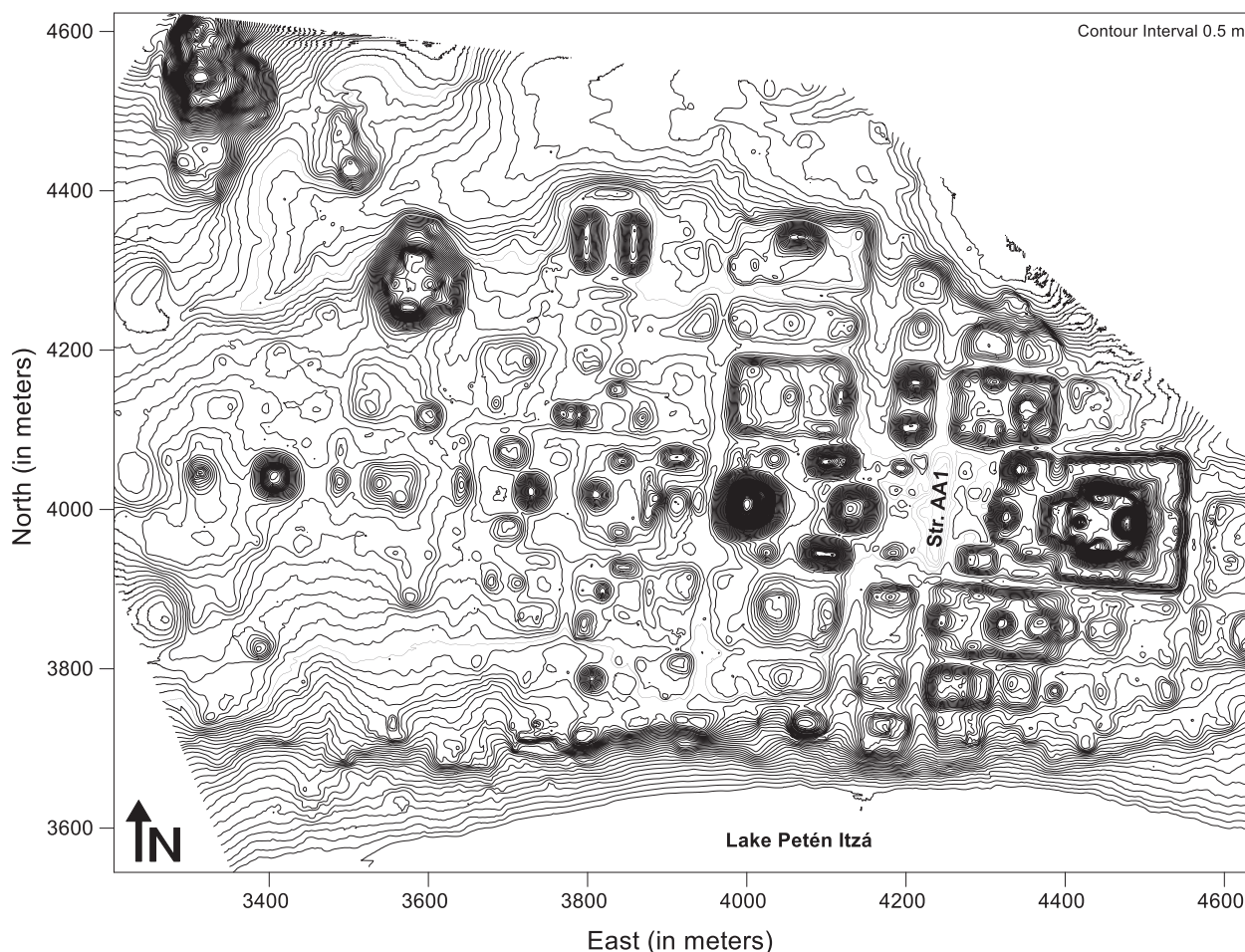


Fig. 1. Map of the gridded site Nixtun-Ch'ich', Petén, Guatemala, showing the location of Structure AA1.

Florida Museum of Natural History (FLMNH), University of Florida (UF), Gainesville, to investigate its properties and explore why early builders might have incorporated it into their structures. This report presents the findings of physical, mineralogical, and soil nutrient (chemical) analyses and their implications. We conclude that these sediments served a mortar-like bonding function in early architectural construction.

2. Materials and methods

2.1. Materials

The two submitted samples were from 2014 excavations in Structure AA1/1 in the eastern part of the civic-ceremonial core of the site (Chan and Pugh, 2015). This structure is a low, west-facing, elongate north-south platform on the east side of a plaza, one of two primary buildings comprising the Sector AA “E-Group.” E-Groups are the earliest (Middle Preclassic period and later) civic-ceremonial architectural complexes in the Maya lowlands, and are believed to have functioned in horizon-based solar astronomy (see, most recently, Freidel et al., 2017; also Aimers and Rice, 2006; Aveni et al., 2003, among others). An early observer on the western pyramid could gaze across the plaza to the eastern platform and confirm equinoctial and solstitial sunrises over marked points (e.g., stones, wooden beams) on the eastern platform. In later times, the eastern platforms were remodeled and enlarged, three superstructures were built over the solar station points, and carved, dated stelae were often erected in front of the eastern face. Structure AA1/1, however, lacked such elaboration, suggesting an early date.

Structure AA1/1 was investigated by three excavations: a large, irregular unit over the front (west) center; a 1×2 m E-W test sounding (Unit 4003N/4238W), excavated ~ 2.5 m to bedrock, in the north-center of the platform; and another large unit (3991N/4248E) over the rear (east) façade. Of the two submitted samples, #64 (CTL sample 1; hereafter analysis sample #64-1) was extracted from the test unit near the center of Structure AA1/1 (Fig. 2). It came from Level 5, a ~ 70 cm-thick deposit of Middle Preclassic construction fill overlying 30–35 cm of fills atop bedrock, dated to the Middle Preclassic and Terminal Early Preclassic (Pre-Mamom; pre-900/800 BCE) periods. The second, smaller project sample, #15 (CTL sample 2; hereafter analysis sample #15-2), was from excavations into the eastern (back) façade. Here the material represented a 5–10 cm-thick bonder for dressed limestone blocks forming the lowest tier of the stairway access or a stepped back wall (see Figs. 2 and 3; Chan and Pugh, 2015: Figs. 48, 49. The sample was from smaller Unit 3991N/4245E, south of the E-W centerline). Similar material was noted in Level 9, bedrock leveling, in an adjacent unit (Chan and Pugh, 2015: 50, 52).

2.2. Methods

2.2.1. Physical properties

Characterization of the physical properties of the two samples followed CTL protocols (Cordell et al., 2017). The first step was particle-size analysis: wet-sieving through a set of USDA sieves. Analysis sample #64-1 was large enough that a range of properties of this material also could be explored. For example, a test bar (#64-1a) was made for measuring water of plasticity (%WP) and linear drying shrinkage (%LDS). After air-drying for a week, the bar was very hard and was placed

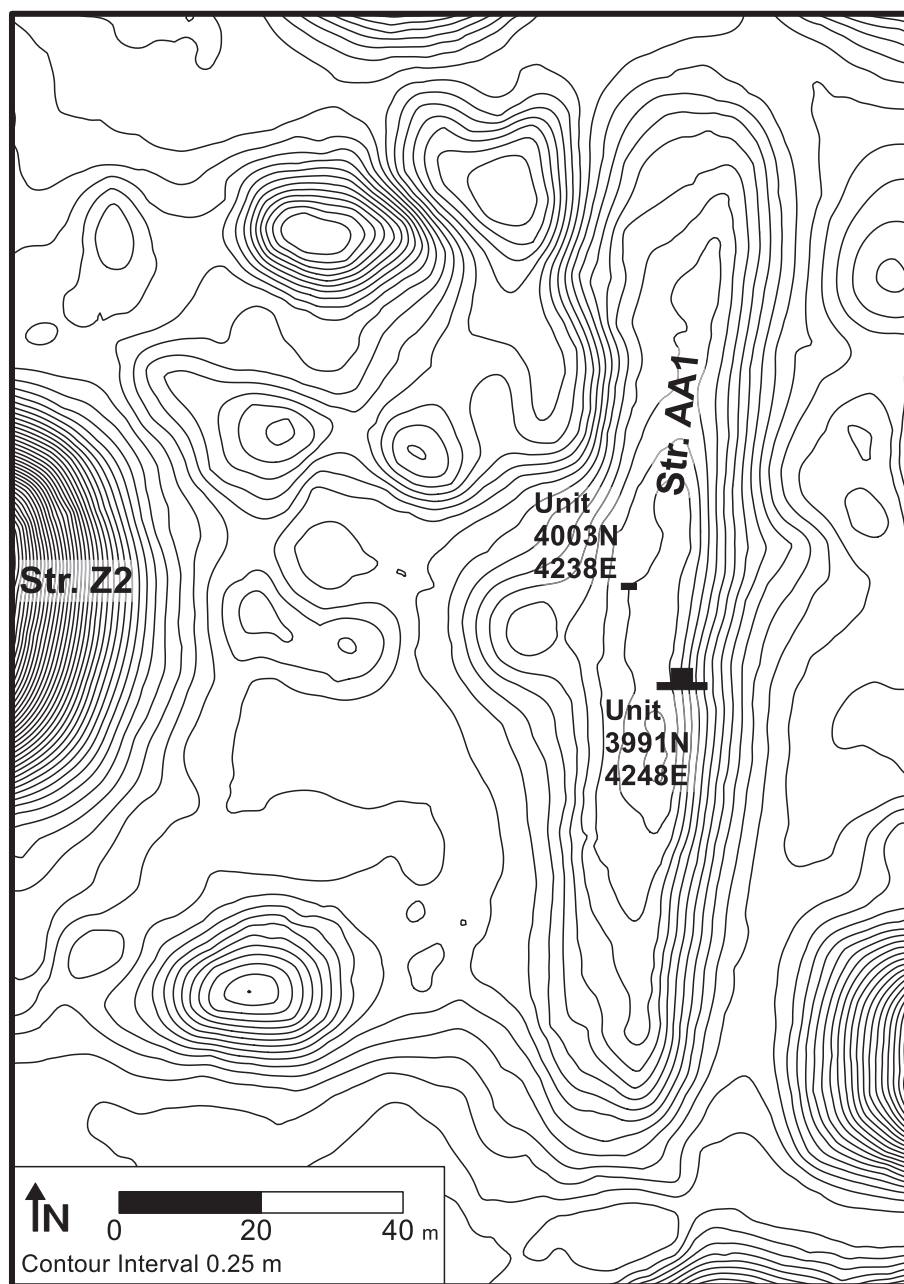


Fig. 2. Locations of select excavation locations, Structure AA1, Nixtun-Ch'ich'.

in a drying oven at 110 °C for an hour. Test bar #64-1b was cut into five tiles for stepwise firing at temperatures from 400 °C to 800 °C, with a 30-minute holding time at each, to assess such firing weight losses (%FWL).

In addition, loss on ignition or %LOI was calculated. LOI is a test performed on soils or other sediments to measure the content (% weight) of organic matter and volatiles lost when subject to heat (“ignition”). It is calculated as $(\text{wt loss/dry wt}) \times 100$. %LOI was calculated for sample #64-1 in two stages: first, after drying in an electric drying oven at 105 °C, and then after heating in an electric furnace at 450 °C for 6 h.

2.2.2. Mineralogy

The mineralogy of analysis sample #64-1 was investigated through petrography in the CTL. A thin section of a sample of the clay fired to 600 °C was analyzed via petrographic microscope, with a total count of 381 points.

X-ray diffraction (XRD) analyses were undertaken in the

Department of Soil and Water Sciences at UF on a light-colored, gravel-sized particle and, separately, on the fine-sieved (< 0.05 mm) fraction of sample #64-1. The gravel particle was ground in a mortar and pestle and packed loosely into a cavity mount. The < 0.05 -mm material was prepared in two ways: packed loosely as a powder into a cavity mount, and dispersed in water. The latter was then collected on a 0.45- μm filter and saturated with Mg by eluting with MgCl solution followed by washing out the salts. The Mg-saturated material was transferred from the filter to a glass slide and heated to 100 °C. The heat treatment was performed to substantiate the peak-shifting behavior of smectite clay in response to dehydration.

These analyses were carried out via a computer-controlled X-ray diffractometer (Ultima IV X-Ray Diffractometer, Rigaku Corporation, Japan) equipped with stepping motor and graphite crystal monochromator. The scans were conducted from 2 to 60° 2 θ at a rate of 2 degrees 2 θ per minute using Cu K α radiation. Minerals were identified by referencing X-ray powder diffraction data for minerals published by the Joint Committee on Powder Diffraction Standards.

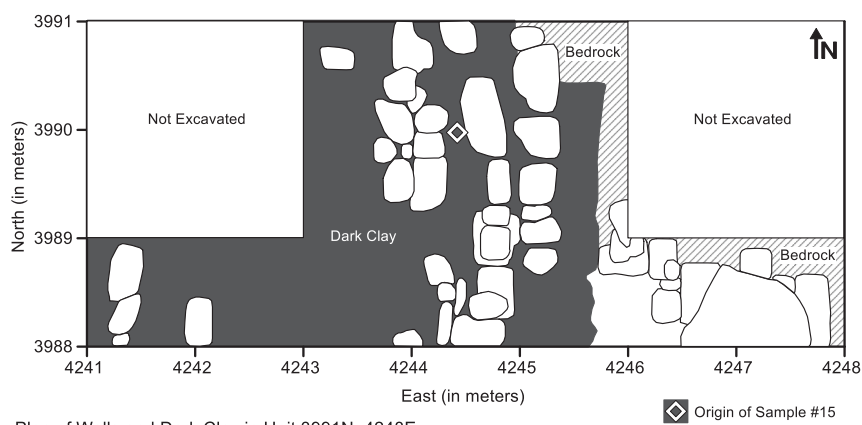
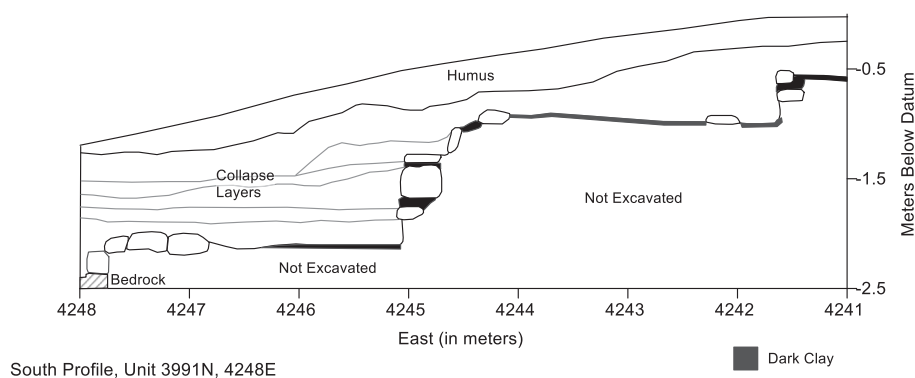


Fig. 3. Plan and south profile of unit N3991/E4248, Structure AA1, Nixtun-Ch'ich'.

Plan of Walls and Dark Clay in Unit 3991N, 4248E



South Profile, Unit 3991N, 4248E

2.2.3. Soil testing and nutrient (chemical) analysis

The fine fraction (clay-sized particles) of sample #64-1 was submitted to the UF Soil Testing Lab for evaluation in terms of suitability for agriculture. Procedures included mixing water with the sample in a 2:1 ratio for pH determination and electrical conductivity, and measuring extractable nutrients—phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), manganese (Mn), and zinc (Z) using the Mehlich-3 extractant reagent. This reagent is composed of 0.2 *N* acetic acid, 0.25 *N* NH_4NO_3 , 0.015 *N* NH_4F , 0.013 *N* H_4NO_3 , and 0.001 *M* EDTA.

3. Results

3.1. Physical properties

Nearly all (97%) of sample #64-1 passed through the finest sieve (#325), indicating the material was composed almost entirely of clay-sized or smaller particles (Table 1). The grains remaining on the sieves included primarily limestone nodules, quartz, and dark clay pellets, plus organics. Quartz grains increased through finer particle sizes, whereas limestone decreased.

Nearly 87% of analysis sample #15-2 passed through sieve #325, revealing that this sample too consisted primarily of clay-sized or smaller particles (Table 2). All size fractions included limestone nodules; quartz was present in all but granule-sizes; and organics were common, including plant fibers in coarser fractions. The finest clay-sized material settled very quickly.

When water was added to the dry sample #64-1 it became very sticky. The air- and oven-dried test bar #64-1a was very hard but crumbled when touched and a dry-length measurement could not be made. The crumbles were reformed into bar #64-1b and, in

acknowledgment that the bar would not survive intact in the drying oven, air-dry length was recorded instead. Measurement of the first and second efforts of %WP and %LDS are given in Table 3. The crumbling of the dry material reveals extremely low “green” (unfired) strength despite its hardness.

In the %LOI tests, sample #64-1 lost 4.25% of its weight on drying at 105 °C, and then 15.4% on heating at 450 °C.

Clays and other similar fine sediments continue to lose weight (and continue to shrink in mass) upon further dehydration on heating (i.e., “firing,” as with pottery) as a consequence of evaporation of water and loss of volatile chemical components (e.g., salts: carbonates, sulfates). Table 4 shows the continued high percentage of firing weight loss for the test pieces of sample #64-1 when fired to higher temperatures. Note that, owing to an oversight, weights were not recorded at 700 °C.

3.2. Mineralogical analysis

Of the 381 points counted in the thin section of sample #64-1, 319 (93.5%) were clay matrix. Forty (3%) of the points were voids, perhaps representing oxidized plant material such as fine rootlets. Of the 22 (6.5%) aplastics counted, only two were silt-sized. The majority of the coarser fraction was very fine to medium quartz sand (3%). The remainder included low frequencies of limestone, shell, clay lumps, ferric material, feldspar, and epidote. Siliceous microfossils—plant remains such as phytoliths, and shells, sponge spicules, and diatoms—were not observed.

XRD revealed that the < 0.05-mm material of sample #64-1 was composed mainly of smectite clay and quartz, with a small amount of kaolinite clay (Figs. 4 and 5). Calcite is possibly present in small amounts as well but its identification is tentative. The gravel particle was composed of calcite. Smectite was identified through the

Table 1Grain-size analysis of wet-sieved^a Nixtun-Ch'ich' sample #64-1.

Particle size			Air-dry Wt ^b		Principal constituents ^c			
Wentworth	Sieve #	mm	G	%	Limest	QTZ	Clay pellet	Other
Granule	5	4.0	0.2	0.31	X			
	10	2.0	< 0.1		X	X	X	
Very coarse	18	1.0	0.1	0.16	X	X	X	
Coarse	35	0.5	0.1	0.16	X	X	X	Organics
Medium	60	0.25	0.2	0.31	X	X	X	Organics
Fine	120	0.125	0.3	0.47	X	X	X	Organics
Very fine	170	0.09	0.3	0.47	X	X	X	Organics
Silt	325	0.045	0.7	1.1	X	X	X	Organics
Mostly clay		< 0.045	62.0	97	Very dark gray clay			

^a 74.4 g dry weight; 10.5 g lost in processing (63.9 g remaining).^b Amount left on sieve.^c As seen with a binocular microscope at 10 × magnification.

magnesium saturation as well as heating, which altered the spacing of the peaks in the range of 14 to 20 Ångströms in a manner consistent with that mineral (Figs. 5 and 6).

3.3. Soil testing and nutrient (chemical) analysis

When the usual 2:1 water:soil mix was prepared in the UF Soil Testing Lab, sample #64-1 exhibited unusual behavior: It took up all the water, became “thick as pudding,” and could not be filtered. The pH of 7.8 mirrors the waters of Lake Petén Itzá, but is considered high for crops and would likely present plant nutrition problems. Table 5 shows the Mehlich-3 extractable nutrients and an interpretation in terms of plant nutrition.

The low levels of phosphorus were expected and are characteristic of lowland soils in general (see, e.g., Lawrence et al., 2007). Similarly, the high levels of calcium and magnesium in these materials were expected, given the geology of the lake area. Manganese was also expected, as manganese nodules are often present in the clays used for the region's pottery in ancient times, but the high level of copper is difficult to explain. Concentrations of both metals are sufficiently high that they would likely be toxic for plants in ordinary mineral soils lacking the large amounts of organic matter seen here (> 17% in sample #64-1). An analysis of soils from a 3-m core in a nearby *bajo* (a low-lying, seasonal swamp or wetland), however, also revealed high values of copper (20–50 ppm), as well as some high manganese concentrations (Cowgill and Hutchinson, 1963: 18, 50). The elevated copper might result from accumulation in the organic matter, which has the capacity of strongly holding metal ions, or perhaps from weathering of the marine limestone substrate. Eolian inputs of atmospheric dust, for example, from the Sahara, contribute to soil formation and are a source of phosphorus (Das et al., 2013).

Table 2Grain-size analysis of wet-sieved^a Nixtun-Ch'ich' sample #15-2.

Particle size			Air-dry Wt ^b		Principal constituents ^c			
Wentworth	Sieve #	mm	G	%	Limest	QTZ	Fiber	Other
Granule	5	4.0	0.7	2.2	X		X	Shell fragment
	10	2.0	0.4	1.3	X		X	Rock fragment
Very coarse	18	1.0	0.6	1.9	X	X	X	
Coarse	35	0.5	0.6	1.9	X	X	X	Dark clay pellets
Medium	60	0.25	0.5	1.6	X	X	X	Dark clay pellets
Fine	120	0.125	0.4	1.3	X	X		Dark clay pellets
Very Fine	170	0.09	0.3	1.0	X	X		Dark clay pellets
Silt	325	0.045	0.7	2.2	X	X		Dark clay pellets
Mostly clay		< 0.045	27	86.5	Dark gray clay			

^a 34.3 g dry weight; 3.1 g lost in processing (31.2 g remaining).^b Amount left on sieve.^c As seen with a binocular microscope at 10 × magnification.**Table 3**Mean Water of Plasticity (%WP)^a and Linear Drying Shrinkage (%LDS)^b of sample #64-1a and -1b test bars.

Test bar	%WP ^a	%LDS ^b
1a	71.0	na ^c
1b	54.2	18.0

$$^a \%WP = \frac{\text{weight}_{\text{wet}} - \text{weight}_{\text{dry}}}{\text{weight}_{\text{dry}}} \times 100.$$

$$^b \%LDS = \frac{\text{length}_{\text{wet}} - \text{length}_{\text{dry}}}{\text{length}_{\text{dry}}} \times 100.$$

^c See text.**Table 4**

Weight changes (in g) on firing sample #64-1 to different temperatures (in °C) for calculation of firing weight loss (%FWL).

Temp	Dry Wt	Fired Wt	Wt loss	%FWL
400	6.357	6.066	0.291	4.6
500	9.573	7.812	1.761	18.4
600	7.908	7.056	0.852	10.8
800	9.942	8.603	1.339	13.5

4. Discussion

4.1. Analytical results

Sediment samples #64-1 and #15-2 from Structure AA1/1 represent highly organic, sticky materials composed primarily (86–97%) of fine, clay-sized particles. Inspection under 10 × binocular and petrographic microscopes revealed grains of limestone/calcite and quartz, dark clay

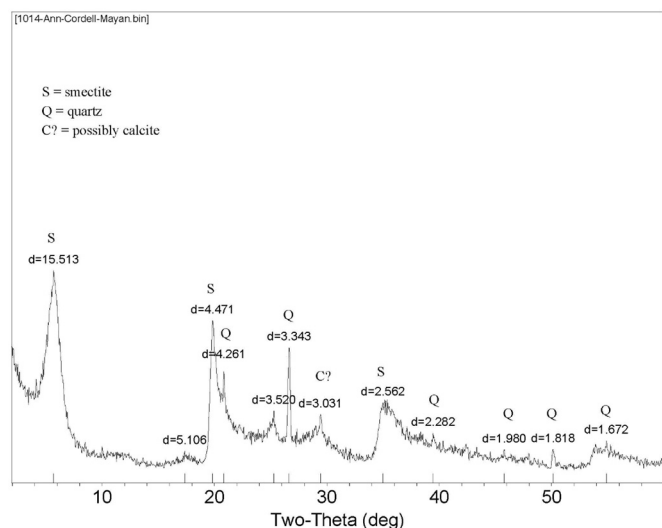


Fig. 4. X-ray diffraction pattern of the finest (< 0.05-mm) soil material of sample #64-1 analyzed “as is” (no controlled cation saturation) as a dry powder in a cavity mount.

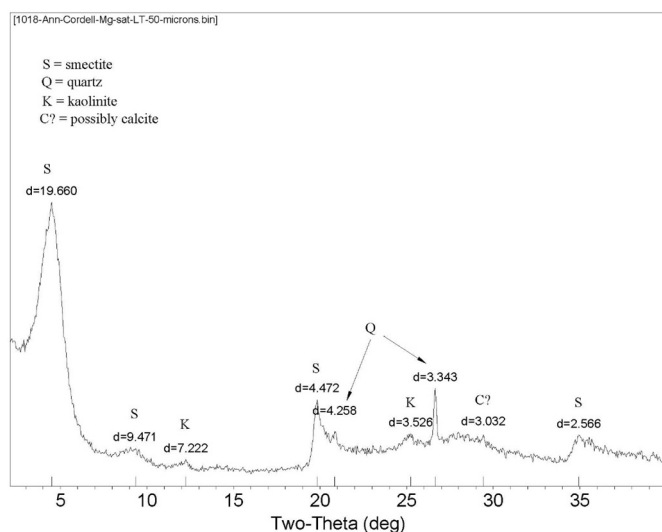


Fig. 5. X-ray diffraction pattern of the finest (< 0.05-mm) soil material of sample #64-1 mounted on a glass slide following Mg saturation, which induces expansion of the 15.5-Å peak (Fig. 4) to > 19 Å.

pellets, and organic matter, including plant fibers.

The test bars formed of sample #64-1 were hard but extremely fragile, crumbling when handled. This fragility reveals the material's low green strength: If it were used to make pottery, for example, the dried, formed vessel probably could not have been safely transferred to the firing location without breaking. Low green strength, plus the extremely high %WP and %LDS of #64-1, are consequences of granulometry: The material consists almost entirely of clay-sized particles. Clays exhibit greater green strength if they incorporate a range of grain sizes, often enhanced for pottery-making by the addition of coarser particulate matter as “temper.” Fine clay particle sizes also result in a larger percentage of pore spaces occupied by water (and organics and salts) (see Rice, 2015: 67–94).

XRD analyses revealed the finest fraction to be composed primarily of smectite clays, plus quartz and possibly kaolinite. Smectite (formerly montmorillonite) is a phyllosilicate clay mineral with an “expanding lattice” or three-layer structure: two silica layers sandwiching an alumina layer. Common in Petén, these clays occur as very small particles and, because they can hold considerable water (and organics and salts) between the layers, exhibit strong properties of swelling with the

addition of liquid. They shrink correspondingly when the water is removed on air drying or heating.

The samples, especially #64-1, were also shown to have high loss on ignition (%LOI), high plasticity (%WP; to the point of stickiness), high drying shrinkage (%LDS), and high firing weight loss (%FWL). Chemical analyses revealed a slightly elevated pH of 7.8 and high levels of six nutrients (K, Ca, Mg, Zn, Cu, and Mn). The phosphorus level was deficient for crop production.

4.2. Source of the material

Why was this organic, clayey sediment used in construction at Nixtun-Ch'ich'? Several possibilities were entertained, but ultimately lacked robusticity. With respect to the presence of this material immediately overlying bedrock, it might have accumulated over—or have decomposed from—the limestone during the Late Pleistocene/Early Holocene transition (c. 18,000–11,000/7000 years ago). In the lowlands, this was a period of climatic fluctuations but overall warming and wetting that led to a rise in lake levels and a change from temperate to tropical forest (Brenner, 2018). This possibility is unlikely, however, because when the underlying bedrock is exposed it frequently shows signs of having been scraped or carved. Moreover, the sediments often include artifacts.

Alternatively, these clayey sediments might have been erosional material (colluvium) deposited in the littoral zone of Lake Petén-Itzá, transported by rainfall runoff. Such waterlain sediments—highly organic, fine-textured, and often high in nutrients—are typically called organic muds. Similar but almost entirely organic sediments are known to accumulate on the bottoms or margins of lakes and are called gyttja. Gyttja (“slime” in Swedish) forms underwater, particularly in calcareous waters, as a “gelatinous precipitate,” olive green to dark brown in color; it contracts and hardens but crumbles when dried (Lachacz et al., 2009: 61–62). The presence of plant fibers in the Nixtun-Ch'ich' samples can be taken to support terrestrial or aquatic origins, but the absence of siliceous microfossils is puzzling. Regardless, the earliest settlers of Nixtun-Ch'ich' carried this colluvial material to what would become their city and placed it upon cleaned and scraped bedrock surfaces.

Comparative data come from Structure 4 at the small site of Buenavista-Nuevo San José, approximately 7 km north-northeast of Nixtun-Ch'ich' and at a higher elevation. A trench into Structure 4 exposed six construction phases, the lowest/earliest of which consisted of leveling and surfacing bedrock with a 6-cm thick deposit of brown clay mixed (“tempered”) with small stones. Pottery incorporated into this material dated to the Terminal Early and Middle Preclassic periods (Castellanos Cabrera, 2007: 15; Castellanos Cabrera and Foias, 2017: 9). Some 47 km to the south, early platform constructions at the site of Ceibal were underlain by deposits of dark clay, possibly brought into the site from nearby wetlands, and placed above scraped bedrock (Inomata et al., 2013: 467–468). Outside the Maya region, in Tomb A at the Olmec site of La Venta, late Middle Formative-period deposits of jade and a shark's tooth were placed on a stratum described by excavators as “blue clay” or “olive green swamp muck” (Reilly, 1989). The objects, the clayey stratum, and the underlying pavement of greenstone slabs all connote watery surfaces and symbolize the mythical watery Underworld. To our knowledge, the materials at these sites have not been given comparable chemical or mineralogical analyses.

In northern Petén, similar clayey materials were noted at slightly later archaeological sites in the Mirador basin. There, sticky, organic sediments were excavated from nearby *bajo* wetlands and brought to the Late Preclassic site of El Mirador to construct gardens and agricultural terraces (Hansen, 2016: 346, 360). *Bajo* soils are thought to be vertisols: heavy clay (smectite/montmorillonite) soils that are often “deficient in phosphorus, potassium, and zinc, low in organic matter, poorly aerated, overly acidic, subject to seasonal shrinking and swelling capable of tearing crop roots, extremely hard when dry, and plastic and

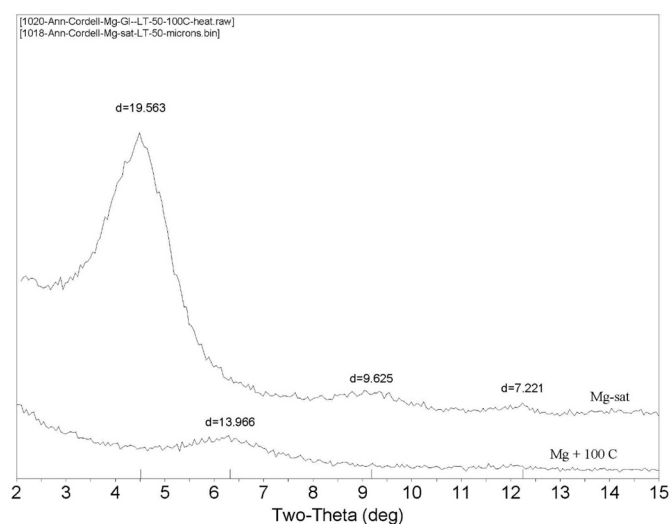


Fig. 6. X-ray diffraction patterns of the finest (< 0.05-mm) Mg-saturated soil material of sample #64-1 showing peak shift toward higher 2θ (decreased d spacing) in response to heat (consistent with smectite).

Table 5
Extractable nutrients in Nixtun-Ch'ich' sample #64-1.

Nutrient	Amount (mg/kg)	Interpretation
P Phosphorus	1	Low (fertilizer with P needed)
K Potassium	112	High
Ca Calcium	> 20,000	High
Mg Magnesium	> 540	High
Cu Copper	17	High
Mn Manganese	257	High
Zn Zinc	6	High

sticky when wet" (Dunning et al., 2002: 271). The Nixtun-Ch'ich' samples show some of these vertisol characteristics, but nutrient analyses do not support this categorization. In addition, no siliceous plant microfossils were observed in thin-section, although these might have been destroyed by bioturbation.

The El Mirador sediments are considered to be "muck," typically described as carbonate-dominated saprist histosols made up of highly decomposed organic matter (< 17% organic carbon (Lindbo and Kozłowski, 2005: 830); compare sample #64-1 LOI of 15.4%), plus mineral matter (clay, silt). Characteristic of wetlands and swamps, mucks are very fertile and good for growing varied vegetable crops, especially root crops. Organic matter in such material oxidizes rapidly once exposed to aerobic conditions, resulting in a drastic reduction in volume. In the Florida Everglades Agricultural Area, for example, a subsidence rate of 2 to 3 cm/yr has been experienced since the organic soils were drained a century ago (Snyder, 1978) and about half that rate in the last four decades. What is left is the mineral matter and organic materials that are highly resistant to decomposition.

As a final consideration, it is possible that some of the Nixtun-Ch'ich' platforms (and those at other sites) were built over ancient gardens. Over time, nutrients were lost and what remained were the clay minerals and very stable organic matter. Thus, the dominant physical properties would be stickiness when wet and hardness when dry. Once walls were built upon it, the underlying material would have been largely protected from repetitive wetting and drying, thus reducing the effects of shrinking and swelling. But because sample #64-1 is a highly organic, mineral-soil material and not muck, subsidence is not likely to have been a concern. Similarly, the impact of shrinkage might have been negligible on sample #15-2, as it was primarily a thin (5–10 cm) bonder. In the case of other occurrences of these clayey materials, thicker and underlying building construction, the impact could have

been significant, however. In general, building on highly organic soil is risky owing to its low load-bearing capacity, a consequence of shrinkage through drying and oxidation of organic matter, and resultant subsidence (Lindbo and Kozłowski, 2005: 831, 832).

4.3. Early Maya plaster and mortar

The above considerations do not satisfactorily explain why these dark, highly organic, clayey sediments overlay bedrock, and underlay or were incorporated into Middle Preclassic stone constructions at Nixtun-Ch'ich' and elsewhere. Overall, it was apparently their "stickiness" that made them a desirable bonding agent or mortar for early Maya builders. They bonded the surfaces of what was above to what was below (or beside) in architectural constructions.

Lime mortar was a constructional innovation that occurred early in the Middle Preclassic period in the Maya lowlands, apparently as early as 1000 BCE as seen in the surfacing of a plaza at Cuello, northern Belize (Hansen, 2000: 120, 139, 220). Nonetheless, it was slow to spread through adjacent regions. The technology of Maya plaster has been most closely investigated at the Middle Preclassic site of Nakbe in the Mirador Basin of northern Petén (Hansen, 2000). There, "crude plaster"—unprocessed from the quarry, with particles up to 2 cm in size—covered low, rough-hewn stone walls around 800 BCE (Hansen, 2000: 99, 188). In addition, "the earliest walls are associated with floors of compacted *sascab*" (soft, decomposed, marly limestone), occasionally with a thin covering of stucco. Similar floors of varying thickness are noted in Middle Preclassic constructions at Nixtun-Ch'ich', with a dense, more compacted surfacing. Although it can be hard, compacted *sascab* is not recommended as a load-bearing mortar (Hansen, 2000: 153, 162).

Evidence of the beginnings of technical innovations in architecture at Nakbe began in the late Middle Preclassic period, after 600/500 BCE, as evidenced by the preparation of dressed stone blocks of fairly consistent dimensions (Hansen, 2000: 100, 222). At Nixtun-Ch'ich' dressed stone blocks were set with the black clay bonder in the back of Structure AA1/1. Although later Maya plasters and mortars exhibit greater uniformity and decreasing particle sizes, it was not until the Late Preclassic (after ca. 200 BCE) that greater, specialized processing control is evident along with the addition of smectite clay to the mix (Hansen, 2000: 188–190, 192–193, 211–212). Only after the advent of good quality mortar were the Late Preclassic and Classic Mayas able to construct their massive lofty temples.

5. Conclusions

The two sediment samples discussed here were extracted from architectural contexts in Structure AA1/1 in the ceremonial core of Middle Preclassic Nixtun-Ch'ich'. Structure AA1/1 is a north-south platform on the east side of an E-Group. Besides the #64-1 sample from Level 5 in the test sounding, black clay was also noted above bedrock in Level 9, as well as in the eastern façade excavations. Elsewhere at the site, sticky dark clays were noted above scraped or carved bedrock in early civic-ceremonial (and other) edifices, and sometimes directly underlying plaster surfacing (floors). At other Petén sites, early structures with similar clayey organic deposits are frequently part of E-Group complexes, the cores of which were carved from marly limestone bedrock knolls (e.g., Estrada-Belli, 2017: 319; Inomata, 2017: 220).

We conclude that, techno-functionally, the dark, organic, clayey sediments found in the Middle Preclassic ceremonial architecture at Nixtun-Ch'ich' (and likely at other sites) were early construction materials that predated burned-lime plasters and mortars. Their stickiness and hardness would have been desirable properties for building, especially as adhesive agents for anchoring architectural stones to bedrock and bonding stone blocks to each other. Excavations in three of four platform corners at one intersection of the Nixtun-Ch'ich' grid's streets revealed lenses at identical levels, indicating that they were part of the

planned construction and executed essentially simultaneously. In other words, the sticky black clay was not a random residue remaining over bedrock as the city took shape.

This prosaic materialist conclusion can be complemented with a symbolic interpretation via analogy with the well-known K'iche' Maya origin/creation myth *Popol Vuh*, recorded in sixteenth-century highland Guatemala. In the beginning, according to this account, there was only the sky and sea, and all was dark. The gods of sky and sea came together and conceived of the creation of earth and its inhabitants. By their words, the earth was formed and the mountain-plain separated from the sea: “The sky was set apart, and the earth was set apart in the midst of the waters” (Tedlock, 1996: 66; also Christenson, 2003: 73). Similar myths about water mountains and watery Underworld origin places are common throughout Mesoamerican prehistory. Perhaps at earliest Nixtun-Ch'ich' and elsewhere in the lowlands, the acts of clearing and carving bedrock into the cores of platforms and depositing sediments from nearby watery places were ritually charged. Such laborious activities represented not only a “conscious break from the previous era and the creation of a new social order” (Inomata, 2017: 220). They also symbolically recreated the mythic primordial unity of the pre-emergence mountain-plain and earth with the sea and watery Underworld.

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Conflicts of interest

None.

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