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From Metaphors to Practice

Operationalizing Network Concepts for Archaeological Stratigraphy

Jessica Munson

Abstract Practice theoretic approaches to archaeological interpretation aim to solve scalar puzzles of structure and agency by employing a set of metaphors that invoke networked relations between people and things in the past. One recent example of this approach, termed "social stratigraphy," offers an alternative to analyzing deeply buried and stratified architectural contexts by emphasizing the recursive social and physical actions of construction, which generate webs of human interaction (McAnany and Hodder, *Archaeological Dialogues 16*(1):1–22, 2009). In order to ensure that such descriptive metaphors align with our empirical observations, archaeologists need to account for the varied ways that social action and architectural practice intersect along multiple axes of variation (*i.e.*, material, spatial, and temporal). By analyzing the interconnected spatial and temporal dimensions of past built environments, this paper suggests that relational concepts can offer more than heuristic functions for archaeological discourse. I offer a set of formal methods related to quantitative social network analyses as one way to operationalize, and thereby strengthen, such metaphors as applied to archaeological interpretation. These techniques are demonstrated using recent excavation data from multiple stratified architectural contexts at a minor temple center located in the Pasión region of the southern Maya lowlands to infer synchronous episodes of construction over a period of 1,600 years (850BCE–850CE). Results of this study demonstrate that issues of spatiotemporal variability can be resolved at a microscale by formally applying network concepts to archaeological analysis.

Keywords Networks · Scale · Stratigraphy · Metaphor · Maya

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Introduction

A central challenge for archaeology involves reconciling varied scales of observed phenomena with appropriate and culturally meaningful forms of explanation. This problem is not unique to the investigation of particular time periods or cultures nor is it specific to certain theoretical perspectives. Indeed, this notion of resolution extends across multiple domains of archaeological observation and interpretation: from the distribution of artifacts across varied units of space to multiple temporal scales in which geological, environmental, and human processes intersect. The analytical units that we commonly impose on archaeological data have further epistemological implications for explanations that interchangeably emphasize the contingent actions of individuals and broader social processes.

Recent attempts to reconcile such explanations and resolve issues of scale in archaeology rely on a set of metaphors that imply networked relations among people and things in the past (Hodder 2012; Joyce and Lopiparo 2005; Knappett 2011; McAnany and Hodder 2009; Mills and Walker 2008; Pauketat 2012; Robb and Pauketat 2013). The potential for such concepts to enhance our understanding of past human behavior and cultural change may be significant, but only if we can demonstrate and verify the empirical linkages that support these relational narratives. In particular, this approach requires that we account for varied domains of social interaction by examining how these dimensions of social action and practice intersect each other across multiple axes of material, spatial, and temporal variation. This paper suggests that network metaphors offer more than a heuristic function for archaeologists by demonstrating that these concepts can be operationalized in a quantitative framework and contribute to resolving some of the scalar problems for archaeological stratigraphy.

In this paper, I present a set of formal methods for analyzing the interconnected spatial and temporal dimensions of past built environments and evaluating practice-based interpretations of complex stratified archaeological remains. I outline this approach and demonstrate its effectiveness for resolving issues of chronological and intra-site variability related to monument construction in a small Preclassic Maya community. To begin, I discuss some of the ways archaeologists have applied practice theoretic perspectives and network metaphors to interpret variable scales of archaeological phenomena. One approach in particular, termed “social stratigraphy,” advocates for a set of conceptual tools and metaphors applied to traditional stratigraphic techniques to interpret the varied actions and tempo of strata formation observed in the archaeological record (McAnany and Hodder 2009). I argue that such conceptual metaphors are actually based upon formal principles and techniques analogous to methods drawn from social network analysis and quantitative approaches first applied by Bourdieu's theory of practice (Breiger 2000; de Nooy 2003). These techniques are demonstrated for archaeology using recent excavation data from multiple stratified architectural contexts at a minor temple center located in the Pasión region of the southern Maya lowlands (Munson 2012). This approach measures similarities among multilayered stratified units using a combination of multivariate techniques to infer synchronous episodes of construction throughout Caobal's 1,600-year occupation history. Results of this study demonstrate how issues of spatiotemporal variability can be resolved at a microscale by formally applying network concepts to archaeological analysis.

Issues of Scale and Metaphor in Archaeological Theory

Of the temporal and spatial dimensions of archaeological phenomena, the former perhaps poses the greater challenge for generating meaningful and reliable explanations of past human behavior. Part of the problem lies in matching scales of explanation to phenomena being explained (Kuhn 2013; Levine 1992). Kuhn (2013) recently makes this point by addressing the relationships between local patterning found in the assemblages at Üçağızlı Cave with continental-scale transitions during the Early Upper Paleolithic. Likewise, archaeologists are pressed to also account for varying tempos of cultural change, which can be particularly challenging for interpretative approaches that seek to link ethnographic and archaeological time scales. While Kuhn (2013, p. 195) is skeptical of such narrative accounts for Paleolithic archaeology, we should be equally judicious when considering explanations of short- and long-term social processes in situations with more detailed and fine-grained datasets.

Practice theoretic approaches to archaeology have often favored proximate explanations, which typically rely on detailed and descriptive accounts of daily lived experience as interpreted from the material record (Pauketat 2001). However, others critique approaches such as historical processualism (HP) for not providing a falsifiable framework to evaluate logical connections between the practices being described to the processes purportedly being explained (O'Brien and Lyman 2004). In response, Pauketat (2004) argues that the goal of assigning ultimate causality is simplistic and unjustified for archaeology. Instead, he favors explanations of human history that require “painstakingly detailed and warranted arguments that measure cultural diversity and change at multiple scales and degrees of temporal resolution” (Pauketat 2004, p. 202). Although archaeologists have established and adapted methods for measuring artifact diversity (*e.g.*, Leonard and Jones 1989), the central challenge remains linking theoretical expectations about diversity with archaeological phenomena observed at variable scales. Despite the polemic undertones expressed from both sides, this debate has arguably encouraged the development and refinement of HP approaches to more clearly articulate the intersection of small-scale human practices with large-scale cultural patterning (see Robb and Pauketat 2013).

Practice theory perspectives in archaeology purportedly provide a solution to these issues of explanatory scale. Specifically, historical processualism distinguishes itself from other agency approaches by emphasizing *relationships* over aspects such as materiality, agents, and intentionality (Robb and Pauketat 2013, p. 14). The point here is that along the explanatory continuum, social practices and agency can be redefined as relational networks through detailed narrative accounts, just as archaeologists can reconstruct relational histories by “observing the interplay of multiscalar factors” (Robb and Pauketat 2013, p. 26). These intersecting and overlapping relations thus become the *explanadum* for practice theory approaches to archaeology. Yet, there is still no clear method to evaluate how the *explanans* fit together in any systematic manner beyond reinvoking a network metaphor. To emphasize this point, Joyce and Lopiparo note that “it is particularly striking to us that archaeologists…use similar *metaphors* or models to explore agency, practice, or habitus” (2005, p. 368, emphasis added). Since the publication of that article, archaeologists have adopted such neologistic cues as webs, chains, bundles, layering, entanglement, and other theoretical terms to connote the idea of relational meaning and networked interaction (Hodder 2012; Joyce 2008; Knappett 2006; McAnany and Hodder 2009; Pauketat 2011; Robb and Pauketat 2013), signaling a shift to the use of relational metaphors as a way to explore the connections between structure, agency, and history for interpretative archaeology.[1]

While this conceptual vocabulary provides archaeologists terms to describe and think about these connections, in my view, it is limited in its ability to evaluate degrees of relatedness between people and the things we study in any systematic way. Formal definitions and methodologies derived from social network analysis can offer ways to apply these concepts with rigor and consistency (Wasserman and Faust 1994).[2] Common in both scientific and humanistic discourse, metaphors can still be important and useful literary devices for the exposition of theoretical ideas (Maasen et al. 1995). When used effectively, metaphors powerfully and actively facilitate the production of novel ideas and understandings by drawing our attention to alternative ways of looking at evidence (Maasen 1995; Tilley 1999, pp. 6–11). However, mapping a set of ideas or principles from one discipline to another does not substitute for empirical understanding nor does it help us distinguish one conceptual framework from another (Bamforth 2002). In the case of the network metaphor, it remains unclear how one can address the cross-cutting and scalar effects of practices or processes without addressing the different connotations of these conceptual terms. Indeed, the credibility of such metaphors can rightly be called into question if based upon weak principles of connection, similarity, and selection (Lakoff and Johnson 1999, pp. 60–73; Wylie 2002, pp. 136–153). For interpreting network relations, archaeologists thus need ways to ensure that the contexts and artifacts we are describing are representative, precise, and comparable along multiple dimensions and at various scales of analysis.

(De)Constructing Stratigraphy

Practice theory perspectives that invoke network metaphors have recently been applied to archaeological stratigraphy to explain the temporal and social relationships among past depositional practices (Joyce 2008; McAnany and Hodder 2009; Mills and Walker 2008). In order to build more convincing understandings of past lived experience, practice theory claims to guide archaeological interpretations of stratified architectural contexts by emphasizing the social and physical actions of construction, the historical and cultural conditions of built environments as well as individuals engaged in the construction process. While such approaches may provide access to

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[1] Additional examples of conceptual metaphors referring to the interconnectedness of past people and things include the notion of a bundle drawn from Keane's (2005) writings and Küchler's (2002) work on *Malanggan* carvings. In addition, the emphasis on network metaphors as applied to practice theory perspectives in archaeology is also substantially influenced by actor-network theory (Latour 2005).

[2] As an example, the notion of a "relation" is a fundamental concept among social network analysts, which has a specific definition. In this case, a relation refers to "the collection of ties of a specific kind among members of a group [where]...the ties themselves only exist between specific pairs of actors" (Wasserman and Faust 1994, p. 20).

the social, material, and temporal dimensions of past architectural practices, extant technical questions remain for archaeologists' reading of the stratigraphic record as well as issues of equifinality.

McAnany and Hodder (2009) outline a model based on this approach termed “social stratigraphy,” which includes a set of conceptual tools and metaphors for interpreting the varied actions and tempos of strata formation. Social stratigraphy aims to enhance the traditional way archaeological contexts are analyzed by employing descriptive terminology to interpret different processes and techniques of “stratigraphy-making” (McAnany and Hodder 2009, pp. 7–8). Following the heavily descriptive methodology of most practice-based analyses (Joyce and Lopiparo 2005, p. 369), a set of gerunds references the sequences of physical and social actions that produced different types of archaeological deposits (McAnany and Hodder 2009, p. 9). Three general techniques (*i.e.*, adding, subtracting, and relocating) represent the basic methods for creating stratified cultural deposits, while terms like “avoiding,” “raising,” “erasing,” “remembering,” and “forgetting” are used to amplify the social dimension of the stratigraphic record. This approach arguably builds connections between the physical acts of construction and the social actors who created and derived meaning from ancient buildings in order to describe the “webs of human interaction” that is the objective of social stratigraphy (McAnany and Hodder 2009, p. 3).

The strength of these metaphors and the interpretations that rely on them, however, depend in large part upon demonstrating clear empirical linkages between stratified contexts. As discussed above, the complexities of this problem cannot be underestimated, especially when dealing with multi-scalar archaeological phenomena. The spatial and temporal domains of social life are observable through the archaeological record, yet intersect in ways that may be difficult to disentangle for analytical purposes. Despite several examples that address the temporality of architectural and depositional histories (Blake 2011; Gillespie 2008; Joyce 2004; Pauketat and Alt 2003), practice-based approaches to archaeological stratigraphy have not yet convincingly addressed how spatial variations in strata formation cross-cut the temporal domain.

If we take the objectives of social stratigraphy as our goal and want to employ the network metaphor to its full potential, we must consider how these axes of variation intersect at multiple levels. The temporal dimension of social stratigraphy is essential for delineating sequences of building events, estimating rates of construction as well as reconstructing the social consequences of depositional activities. Intrasite spatial variations among stratified excavation units also provide important contexts for uncovering and examining the social interactions that took place in built environments as well as people's changing relationship to their physical surroundings. The episodic and durational nature of construction events may express degrees of human intentionality and agency that are less accessible through traditional stratigraphy studies (McAnany and Hodder 2009, pp. 5–7). However, it is equally important to situate these repeated practices within their wider architectural and social settings. Built landscapes are dynamic environments in variable stages of construction, renovation, and abandonment (Stanton and Magnoni 2008). Capturing this spatial variation and the rate of construction are equally essential for understanding the social processes that accompany past architectural practices. Thus, the challenge for social stratigraphy is to establish a relevant basis for inferring similarities among stratified deposits from discrete locations.

While the conceptual framework proposed for social stratigraphy draws attention to the social dimension of people's circumscribed actions, its toolkit does not reject existing techniques for studying stratigraphy. Several “augmentative techniques,” derived from geoscience, biology, and geography, are identified as potentially beneficial analyses (McAnany and Hodder 2009, pp. 19–20). Included among these are quantitative approaches, although how these techniques may enhance practice-based interpretations remains to be demonstrated. In my view, practice-based approaches to stratigraphic interpretation need to explicitly address suitable methods for estimating rates of strata formation, analyzing sequences of nonadjacent stratified deposits, and making comparisons between stratigraphic contexts that appear to have formed under similar conditions in order to derive confident statements about past social relations. While these may sound like mundane technical issues for the field archaeologist, the unique circumstances of past depositional practices and formation processes means that not all archaeological cases can be treated equally or uniformly. In this paper, I argue that practice-based interpretations of stratified architectural remains can be improved by demonstrating how these dimensions of social action cross-cut the spatial and temporal domains of the archaeological record. In particular, the application of formal methods that account for spatial and temporal variation in past built environments can strengthen archaeological understanding and theoretical terminology about the relationships between past people and places, and move towards building epistemic linkages between practice and process.

(Re)Constructing Layers of Time at Caobal

This study draws together multiple lines of evidence and analytical techniques to reconstruct a detailed sequence of platform construction, residential occupation, and ritual practices spanning nearly 1,600 years at Caobal, a minor center located in the Pasión region of the southern Maya lowlands (Fig. 1). The site is situated on a high knoll overlooking the Río Pasión and was first recorded in 2006 as part of a survey to relocate and document minor ceremonial centers in the area originally investigated by the Seibal Archaeological Project (Munson 2006; Munson and Inomata 2011; Tourtellot 1988; Willey et al. 1975). Excavations of several structures surrounding the main plaza were undertaken in 2008 and 2009 with the objective of reconstructing how this minor center grew and changed over time (Fig. 2). Results of this investigation indicate that Caobal was a small community that invested heavily in architectural projects during the Preclassic period (ca. 850BCE–250CE) and continued to be a site of ceremonial activity and construction during the Early (250–400CE) and Late Classic periods (600–850CE) (Munson 2012).

Multiple occupations, repeated construction events, and the duration of these settlement patterns contribute to a complex stratigraphic record that poses significant challenges for interpretation (Fig. 3a–d). On the surface, the cluster of mounds defining Caobal's temple precinct resemble the form of other minor temple groups near Ceibal (Munson and Inomata 2011). These minor temple groups may have been local centers of ceremonial activity for dispersed populations (Tourtellot 1988, pp. 425–426); however, the spatial layout of surface remains tells us very little about earlier architectural plans obscured by the overburden of later buildings. In order to

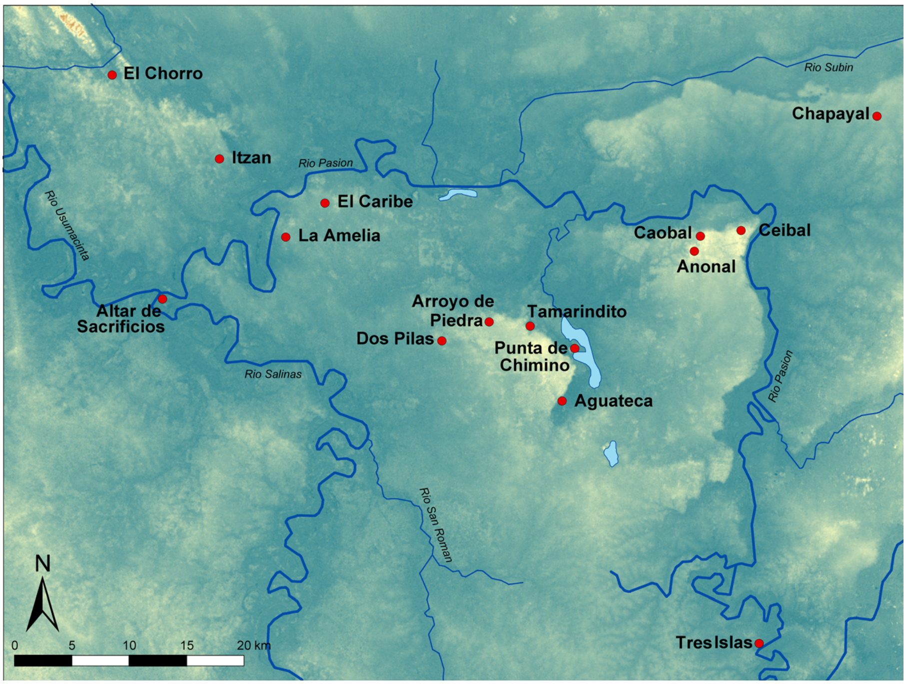

Fig. 1 Location map of Caobal relative to other archaeological sites in the Pasión region of southern Petén, Guatemala

understand when and how these minor centers became nodes of social, political, and religious significance for local communities like Caobal, we must first establish the precise sequence of architectural practices and the relationships between these building events across the site. While this may be a straightforward exercise in some archaeological circumstances, this case is further complicated by the chronological resolution of ceramic and radiocarbon data discussed in more detail below.

By the time Gordon Willey completed work at Ceibal, archaeologists were well-aware of the tripartite suite of data necessary to build site chronologies: stratigraphy, ceramics, and radiocarbon dates (Willey 1968). These were the mainstay of culture history and remain the empirical foundation for much archaeology (O'Brien and Lyman 1999); however, in cases where ceramic or radiocarbon data cannot provide the detailed temporal resolution proposed by social stratigraphy, what can archaeologists do? The objective of this study is not to refine the ceramic chronology for Caobal, as this is well-established for major sites in the Pasión region (Adams 1971; Bachand 2007; Foias 1996; Inomata 2011; Inomata et al. 2013; Sabloff 1975). Instead, the analyses described here are aimed at recovering a fine-grained sequence of architectural practices that accounts for various social and material changes in Caobal's built environment. In doing so, this study demonstrates how relational methodologies can operationalize network concepts for archaeological analysis and resolve issues of spatiotemporal variation at a microscale.

This study combines multivariate analyses familiar to archaeology and formal network analysis as a way to build linkages between the physical practices that we observe to the social processes that we attempt to explain. First, I follow the

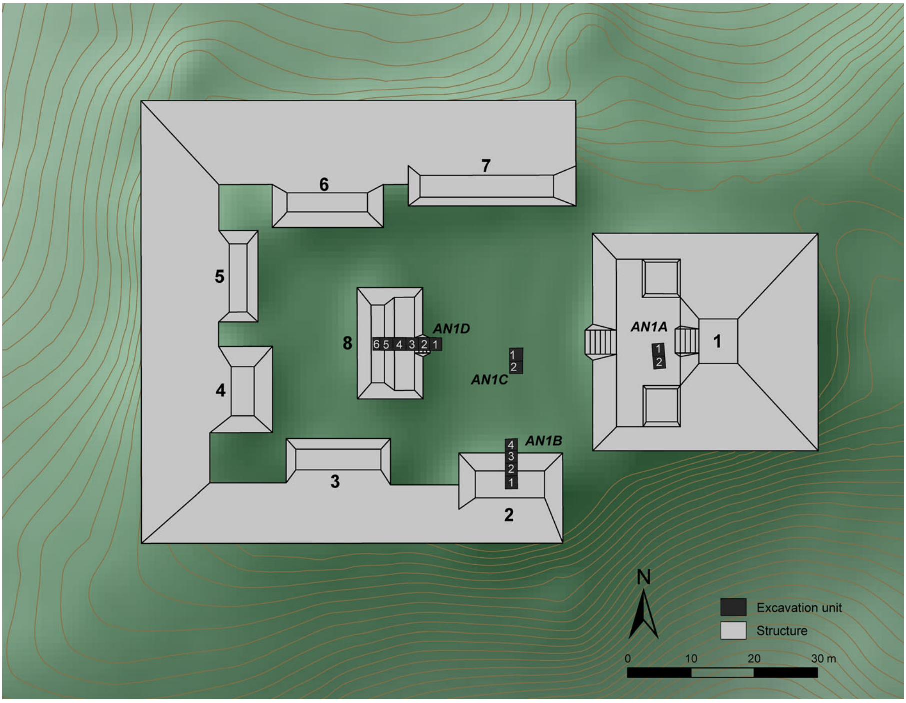

Fig. 2 Settlement map of Caobal's temple precinct showing the location of excavation units and buildings discussed in this study

recommended and well-established use of correspondence analysis to develop a course-grained seriation and extend chronology to contexts without radiocarbon dates. I then propose an additional measure of similarity using cluster analysis to refine this seriation and correlate multilayered stratified deposits. This technique permits identification of synchronous episodes of construction between noncontiguous excavation units within the site. The temporal and spatial resolution of these results permits a fine-grained sequence of architectural practices that demonstrates how this minor center grew and changed over time. Contextualizing these quantifiable changes in the built environment in terms of the actions and social practices that created these deposits can thereby strengthen metaphors of connectivity used in archaeological interpretation.

Network Methods for Archaeological Metaphors

Metaphors, such as the concept of network relations discussed above, can convey complex principles in a rigorous manner, but only if they are accompanied by a disciplinary toolkit that translates and evaluates these terms as formalized statements of observation.[3] Seeking to advance a more robust toolkit for practice theory,

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[3] Knox *et al.* (2006) review the history of network ideas in anthropology and sociology and discuss how their application in these fields follows divergent trajectories. This may also help explain the current split among archaeological applications of social network analysis and more metaphorical use of relational concepts.

Fig. 3 **a**–**d** Stratigraphic profile drawings from **a** Op. AN1A, **b** Op. AN1B, **c** Op. AN1C, and **d** Op. AN1D

sociologists argue that relations between material practices and symbolic constructions, and the mutual constitution of these elements (*i.e.,* agency and structure), can be systematically studied using formal methods without reinforcing structuralist modes of practice theory (Breiger 2000). This relational methodology generally involves the application of social network analysis or a related technique, correspondence analysis (CA), to measure and visualize these connections. As argued for a theory of practice, the latter technique typically satisfies the requirements for relational thinking (Bourdieu and Wacquant 1992). However, an argument can be made that there is essentially no

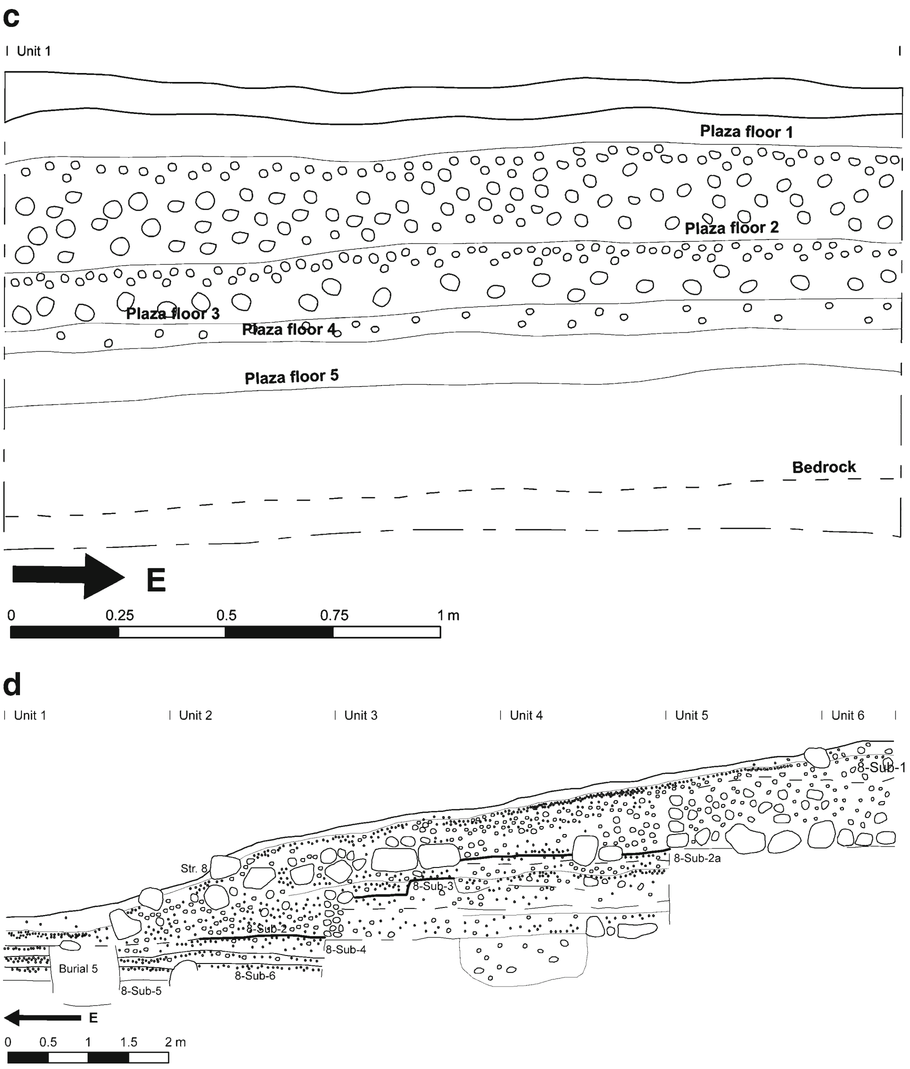

Fig. 3 continued.

technical difference between social network analysis and correspondence analysis, provided that one accepts the recursive idea that "practice within a field is at least partly responsible for the field's structure" (de Nooy 2003, p. 322).[4] Many sociologists recognize this compatibility and apply both social network analyses and similar matrix-based approaches (*e.g.*, correspondence analysis) to model multidimensional social relations and address questions about the relationships between process, structure, and action (Breiger 1979, 2000, 2004; Breiger and Mohr 2004; Edling 2002; Pattison and Breiger 2002; Sonnett

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[4] To further illustrate this point, many software programs designed for social network analysis also include multivariate functions and measures of similarity such as correspondence and cluster analyses (Borgatti *et al.* 2002).

and Breiger 2004; White et al. 1976). Indeed, relational data that record the strength, direction, or frequency of interaction are commonly notated in contigency tables and are better suited to matrix-based analyses, which may not always result in the representation of traditional network graphs (Wasserman and Faust 1994, pp. 76–79).

While social network analysis is beginning to gain purchase among archaeologists as a way to address broad questions about regional interactions and social relations in the past (Brughmans 2012; Golitko et al. 2012; Knappett 2013; Mills et al. 2013; Mizoguchi 2009; Munson and Macri 2009), there are few archaeological examples that employ such sociometric or algebraic notation (but see Scholnick 2010; Scholnick et al. 2013) and fewer still that examine intersecting practices and social relations at the microscale. Moreover, in making inferences about past social processes from artifact data, we need to be aware of the differences between interaction and intersubjective relationships according to practice theory and be careful to avoid unnecessary reductionism (de Nooy 2003, pp. 319–324; Maasen 1995). For archaeology, and an approach like social stratigraphy in particular, this means that we need to select the relational methodology which best fits the data and our assumptions of the underlying relations we seek to understand.

Similarity Measures for Stratified Assemblages

This study employs a set of multivariate analyses to measure the degree of similarity among diverse practices that created stratified archaeological deposits. Archaeologists have long recognized the power of correspondence analysis for the purpose of identifying spatiotemporal patterns among archaeological assemblages; however, its limitations for analyzing complex stratified contexts at multicomponent sites has only begun to be investigated (Peeples and Schachner 2012). As an augmentative technique of social stratigraphy, correspondence analysis is identified as one of the quantitative methods that could benefit from the list of gerunds applied to network metaphors and stratigraphic interpretations (McAnany and Hodder 2009, p. 21). However, as discussed above, correspondence analysis is just one of various relational methodologies for uncovering mutually constitutive elements and formally representing the structural properties of such linkages (Breiger and Mohr 2004). While this technique has a longer history among European archaeologists (Bertelsen 1988; Djindjian 1985), it has only recently gained attention by North American archaeologists for deriving reliable frequency seriation diagrams (Duff 1996; Neiman and Alcock 1995; Peeples and Schachner 2012; Ramenofsky et al. 2009; Smith and Neiman 2007). This study builds upon this research by highlighting some of the situations where this technique is challenged to resolve some of the multiscalar objectives of social stratigraphy, and proposes an alternative measure to identify spatiotemporal relationships between nonadjacent stratified deposits at multicomponent sites.

I suggest that the integration of these formal methods does not reduce stratigraphy to a "neutral mechanism" (McAnany and Hodder 2009) nor am I calling for a "prescriptive methodology" (Joyce and Lopiparo 2005) for analyzing the stratigraphic record. The formal approach described here merely advocates for the incorporation of quantitative methodologies that can systematically account for spatiotemporal variation in the stratigraphic contexts being studied in order to establish a more formal basis for the application of network metaphors in archaeology.

Correspondence Analysis

Correspondence analysis operates on a two-way contingency table in much the same way that matrix-based network analyses function (Breiger 1974, 2000; Breiger and Mohr 2004). As commonly applied to archaeology, the rows represent individual assemblages and the columns are type frequencies.[5] A fundamental assumption underlying most methods of frequency seriation, including CA, is that the attributes or objects measured in the columns follow the standard battleship shape frequency curve. The set of ceramic attributes included in this analysis approximates this unimodal response pattern for the discrete excavation loci, suggesting that a similar dimension of variation exists within the total dataset (Fig. 4). Correspondence analysis seeks to solve this problem by identifying this axis of variation across all combined assemblages in the dataset.

The rows and columns of data can be decomposed along successive dimensions of variation and numeric scores assigned to the axes in such a way that deviations from the independence model are best approximated. When scaled properly, the scores offer a way to measure clustering among the assemblages and types in multidimensional space. A common and not unwelcome result is a plot shaped like an arch or parabolic function. The appearance of the arch is regarded as unproblematic for archaeology and signals that type frequencies follow a unimodal response model with a gradient long enough to capture some dimension of variation (Neiman and Alcock 1995; Ramenofsky et al. 2009; Smith and Neiman 2007). In the case studies cited above, the “arch-effect” is a sign of successful seriations in that the single underlying gradient is time, although this need not be true for all cases. There exist several excellent descriptions of correspondence analysis written for archaeology which outline the mathematical basis for this method in greater detail (Baxter 1994, 2003; Baxter and Cool 2010; Shennan 1997).

For this study, assemblages were analyzed using a sample of temporally sensitive ceramic types recovered primarily from architectural fill deposits. The ceramic sample in this study includes 5,276 sherds that were originally classified according to the type-variety system (Gifford 1960, 1976; Willey et al. 1967), following the Ceibal chronology developed by Sabloff (1975). This is drawn from Caobal's total ceramic assemblage (n=13,547) containing representative samples from every major phase of Maya prehistory, from the Middle Preclassic through the Terminal Classic, thus providing a comprehensive chronological dataset to assess changes in the use and construction of this minor center (Munson 2012, Table A.1). Ceramic types

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[5] In other cases, measures other than ceramic counts may be used. For example, to make comparisons between assemblages Cool and Baxter (1999) use the proportion of glass vessels in an assemblage to potentially avoid confounding issues with depositional processes (*i.e.*, recycling of glass, differential disposal practices, *etc.*). This study employs traditional counts as the unit of analysis for CA. Variables selected for inclusion in the cluster analysis were chosen to minimize potential confounds due to differential depositional processes by including multiple artifact classes normalized by the overall size of the deposit (see Table 4).

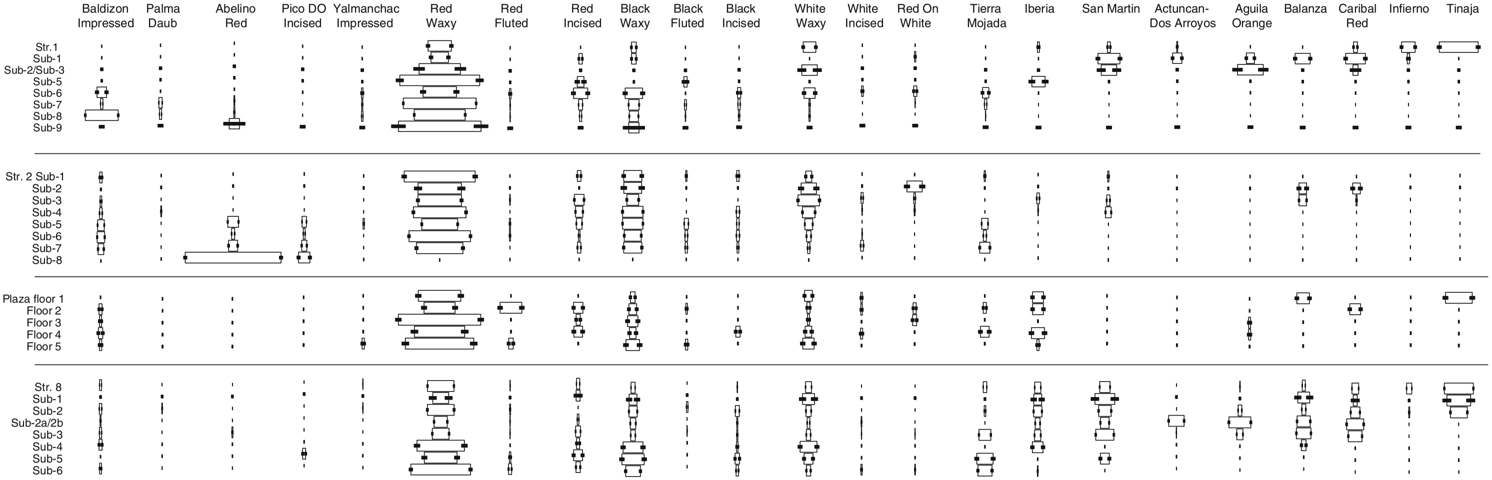

Fig. 4 Seriation plots of ceramic frequency for each excavated loci. See Table 1 for type-variety ware classification

selected for this analysis include diagnostic types and groups based on several criteria described below (Table 1). Nondiagnostic types, including the majority of plain ware types, are excluded from the analysis on the basis that they are less sensitive temporal indicators. However, two types classified in the Achiotes Unslipped ware category are included (*i.e.*, Baldizon Impressed and Palma Daub) due to their identifiable surface treatment and restricted chronological presence (Inomata 2011). Additional measures were taken to ensure that the unimodal response model was not violated due to ambiguous distinctions between some Mamom- and Chicanel-sphere types.[6] In these cases, the Preclassic waxy types were regrouped according to distinctive surface treatments (*i.e.*, slip color and decoration) since preservation issues restricted the identification of vessel forms in many cases. A minimum class size of 20 was also defined to reduce confounding effects of sampling error. In total, 23 ceramic classes were included in the analysis. The average class size contained 244 artifacts, with White Incised being the smallest (n=20) and Red Waxy the largest (n=2,014).

The ceramic artifacts account for a total of 29 excavated assemblages from Caobal that primarily represent architectural levels from major building episodes. The analysis only included those contexts (rows) identified as primary construction events, so that layers identified as bedrock, humus, wall fall or disturbed layers were excluded.[7] In addition, adjacent assemblages related to the same construction event were grouped to improve sample size quality. A minimum sample size of 10 artifacts per assemblage was used to reduce sampling error. The average assemblage contained 181 artifacts with Structure 1-Sub 9 containing the fewest (n=10) and Structure 8 representing the largest (n=701) assemblage.

CA Results

All assemblages and types fitting the criteria described above were included in the first CA. Inspection of the proportion of inertia accounted for by the CA suggests that the dataset is essentially two-dimensional with axis-1 and axis-2 accounting for over 50 % of the total inertia (Table 2). Plotting the ceramic types and assemblages relative to these two axes illustrates that both axes reflect an underlying temporal gradient based on the ordering of the major ceramic complexes (Fig. 5). However, this deserves further explanation. In contrast to the smooth arch-effect expected, the shape of the curve is largely consistent with Smith and Neiman's (2007, pp. 58–59) V-shaped scatter plot of Deep South assemblages. Their results also indicate that the first two dimensions account for time based upon an additional analysis that removed assemblages with large chi-square distances. In the case of Fig. 5, the contribution of assemblage 2-Sub-8 to the first two dimensions is an order of magnitude larger than any other assemblage. In other words, this assemblage accounts for a majority of the

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[6] Seriation diagrams that separate the Mamom- and Chicanel-sphere waxy wares violate the expectation of smooth battleship-shaped curves due to arbitrary separation based on the surface treatment of monochrome-slipped, incised, and fluted types among Flores Waxy and Paso Caballo Waxy wares (Munson 2012, pp. 226–230; Munson and Inomata 2012).

[7] Two construction fill levels were excluded from analysis on the grounds of disturbance (Structure 2 and Patio floor 1). One assemblage was excluded due to small sample size (Structure 1-Sub 4).

Table 1 Ceramic types included in the correspondence analysis. The *left-hand column* includes the original type names. The *right-hand column* includes the reclassified types named according to the ceramic group. Ware classifications are indicated in uppercase lettering

Original type names	Reclassified type names
Achiotes Unslipped (Preclassic)	
Baldizon Impressed	Baldizon Impressed
Palma Daub	Palma Daub
Rio Pasion Slipped	
Abelino Red	Abelino Red
Pico de Oro Incised	Pico de Oro Incised
Yalmanchac Impressed	Yalmanchac Impressed
Preclassic Waxy	
Joventud Red	Red waxy
Sierra Red	
Xexcay Fluted	Red fluted
Alta Mira Fluted	
Guitara Incised	Red incised
Laguna Verde Incised	
Chunhinta Black	Black waxy
Polvero Black	
Centenario Fluted	Black fluted
Zelda Fluted	
Deprecio Incised	Black incised
Lechugal Incised	
Pital Cream	White waxy
Flor Cream	
Nubia Fluted	White fluted
Gordana Fluted	
Paso Danto Incised	White incised
Accordian Incised	
Muxanal rojo y crema	Red-on-white
Mateo red on cream	
Flores Waxy (Preclassic)	
Tierra Mojada Resist	Tierra Mojada
Timax Incised	
SN Orange Resist Fluted	
Paso Caballo Waxy (Preclassic)	
Iberia Orange	Iberia
SN Orange on Cream	
SN Cream and Orange	
SN Orange on Cream Incised	
SN Orange Incised	

Table 1 (continued)

Original type names	Reclassified type names
Playa Dull	
San Martin Variegated	San Martin
Peten Gloss	
Actuncan-Dos Arroyos	Actuncan-Dos Arroyos
Dos Arroyos Orange Polychrome	
Aguila Orange	Aguila Orange
Balanza Black	Balanza
Delirio Plano-relief	
Lucha Incised	
Caribal Red	Caribal Red
Infierno Black	Infierno
Carmelita Incised	
Cameron Incised	Tinaja
Chaquiste Impressed	
Pantano Impressed	
Subin Red	
Subin/Chaquiste	
Tinaja Red	
Tinaja/Pantano	

structure we see in this plot. This is not surprising when we consider that this was the only assemblage to contain exclusively Real-Xe ceramics, indicating that it is the only excavated context to be firmly associating with the early Middle Preclassic phase (ca. 1000–700BCE). The remaining assemblages fall out in a general split between the Preclassic and Classic periods although finer chronological divisions within these clusters are not internally consistent.

Table 2 Results of the first CA. The proportion of inertia accounted for by the first two axes indicates the dataset is essentially two-dimensional

Axis	Eigenvalue	% inertia
1	0.5258	29.10
2	0.4220	23.36
3	0.2967	16.42
4	0.1459	8.07
5	0.0912	5.05
6	0.0755	4.18
7	0.0619	3.43
8	0.0510	2.82
9	0.0345	1.91
10	0.0238	1.32

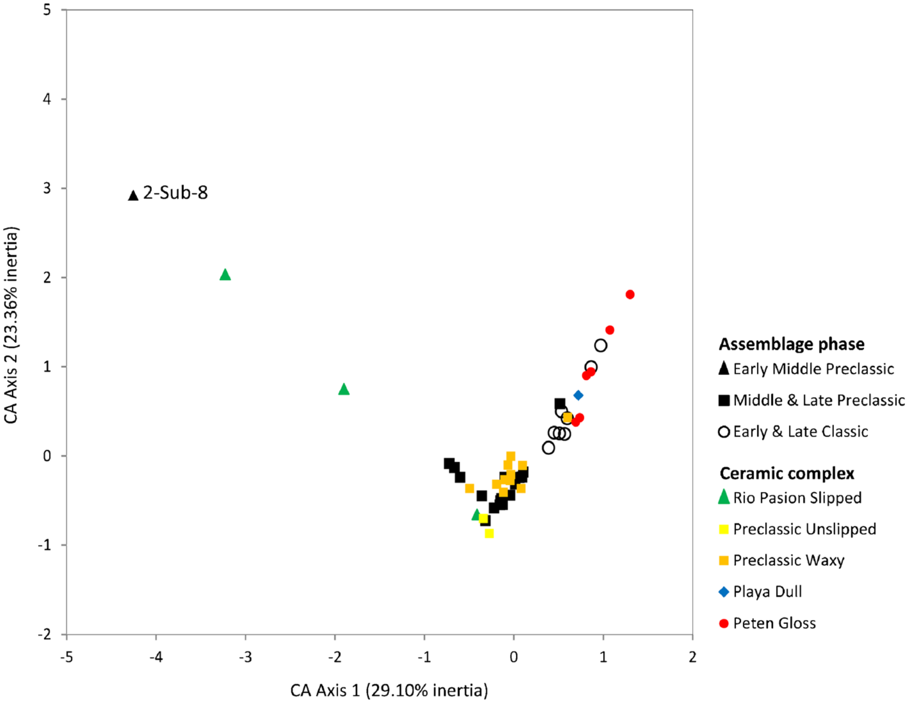

Fig. 5 Plot of the first two axes for the first CA showing the location of assemblages and ceramic types in two-dimensional space. Assemblage 2-Sub-8, on the far left-hand side of the assemblage curve, contributes the majority of structure to this plot. The remaining ceramic types are ordered chronologically by ceramic complex

To test whether the second axis does indeed represent a temporal gradient, we can remove the outlier assemblage (2-Sub-8) and perform a second CA following standard recommendations for such cases (Baxter and Cool 2010, pp. 220–225; Smith and Neiman 2007, pp. 59–60). In this instance, we expect that by removing the large chi-square distance between the single Real-Xe assemblage and the remaining assemblages, the first axis should replicate the second axis from the original analysis. Indeed, this is what happens; yet again, the result does not produce the expected arch-effect characteristic of successful seriations (Fig. 6). Instead, the resulting plot identifies three distinct groups of assemblages defining major periods of Maya prehistory based on absolute and relative dating methods.

Calibrated radiocarbon dates can be used as an independent test of the CA. In this study, eight assemblages were dated using radiometric methods and Bayesian calibration techniques (Munson 2012, pp. 237–253; Table 3). Figure 7 plots the calibrated date ranges relative to the first axis from the second CA. There is general consistency with Fig. 6 for separating major phases of occupation; however, the resolution needed to assess within-phase sequencing is obscured by flattening of the radiocarbon curve for the period between ca. 800–500BCE. In order to obtain more detailed resolution for within-phase assemblage sequence, we need to consider additional lines of evidence and alternative methods for measuring similarity among these architectural deposits.

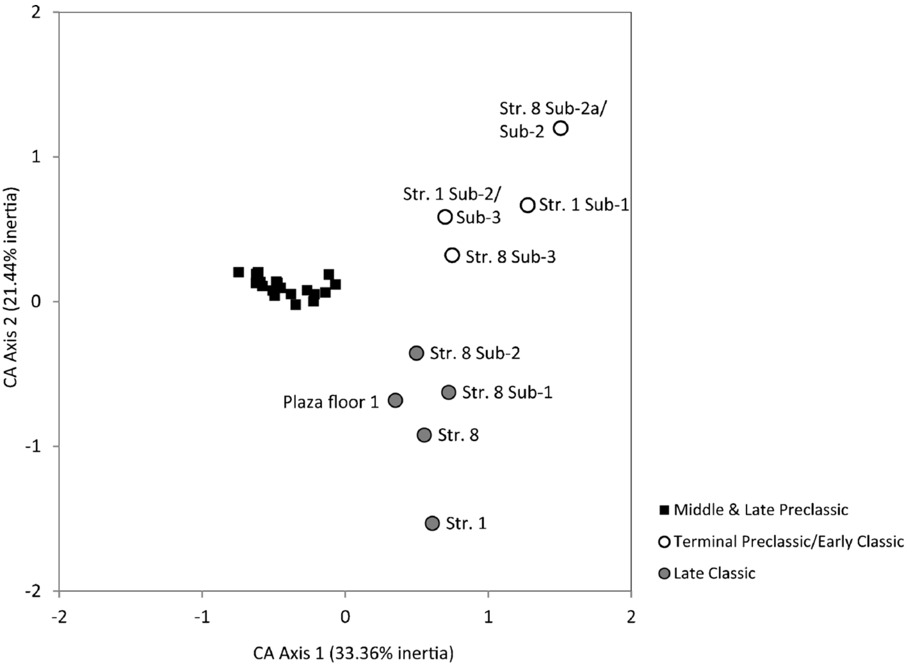

Fig. 6 Plot of the first two axes for the second CA showing the location of assemblages. The plot does not follow the expected arch-effect characteristic of successful seriations; however, the assemblages are grouped according to three major periods of Maya prehistory

Cluster Analysis

Despite the success of CA for generating microseriations (Duff 1996) and resolving site histories from nonstratified contexts (Ramenofsky et al. 2009), there are some confounding factors that may contribute to this technique's inability to resolve within-phase assemblage ordering at multicomponent sites such as Caobal. Part of the problem stems from cultural formation processes of artifact reuse and reclamation of de facto refuse for construction purposes (Schiffer 1987). For these cases, we can consider alternative measures of similarity among multiple stratified assemblages in order to approach the fine-grained seriations required of social stratigraphy.

In some cases, such as the one discussed above, the combination of stratigraphy, ceramics, and radiocarbon data do not provide the level of detail necessary to differentiate within-phase episodes of construction. In an attempt to provide a solution to this problem, we can turn to other lines of evidence to gain a more complete characterization of deposit composition and potentially identify synchronous sequences of construction. Archaeologists are well aware of the different ways in which deposits form as a result of specific cultural, environmental, and geologic processes (Schiffer 1987). In particular, for sites with complex architectural stratigraphy, depositional practices may include reoccupation of the settlement, the incorporation of previously abandoned structures or objects as well as salvaging old building materials and scavenging refuse to be used in the construction of new buildings (Schiffer 1987, pp. 100–114). If our goal is to

Table 3 Calibrated results of radiometric determinations

Sequence number	AAno	Sample ID	Context	Material	UncalAge 14C BP	2-σ CalAge	Bayesian HPD	μ	A	C
1	AA80954	B17	Str. 8	Bone (burial 5, right femur)	1,292±5	651–862 calAD	651-826 cal AD (92.8 %) 841-863 cal AD (2.6 %)	AD 730	99.6	99.3
2	AA80951	B14	Str. 1 Sub-1	Bone (burial 2, right tibia)	1,761±44	137–385 calAD	132-353 cal AD (94.4 %) 370-377 cal AD (1.0 %)	AD 252	96.6	99.6
	AA80952	B15	Str. 1 Sub-1	Bone (burial 3, right humerus)	1,825±47	77–326 calAD	79-255 cal AD (95.4 %)	AD 170	107.8	99.8
	AA80950	B13	Str. 1 Sub-2/ Sub-3	Bone (burial 1, right femur)	1,925±47	39 cal BC– 214 calAD	33-217 cal AD (95.4 %)	AD 119	94.9	99.7
3	AA80947	B4	Str. 1 Sub-6	Charcoal from pit	2,394±49	752–389 cal BC	751-688 cal BC (12.5 %) 668-637 cal BC (5.4 %) 625-610 cal BC (1.6 %) 600-392 cal BC (75.9 %)	531 BC	95.9	99
	AA80949	B12	Str. 1 Sub-8	Organic residue from inside unslipped ceramic vessel	2,542±41	803–539 cal BC	802-704 cal BC (35.3 %) 696-536 cal BC (59.4 %) 530-523 cal BC (0.7 %)	665 BC	96	99.4
4	AA80953	B16	Str. 2 Sub-5	Bone (burial 4, unidentified fragment)	2,487±53	780–415 cal BC	723-410 cal BC (95.4 %)	569 BC	96.3	99.3
	AA80955	B3	Str. 2 Sub-7	Charcoal from pit	2,451±44	757–409 cal BC	769-453 cal BC (95.4 %)	637 BC	98.8	99.6
n/a	AA80946	B3a	Str. 1 Sub-6	Charcoal from pit	3,675±40	2,196–1,943 cal BC	n/a	n/a		

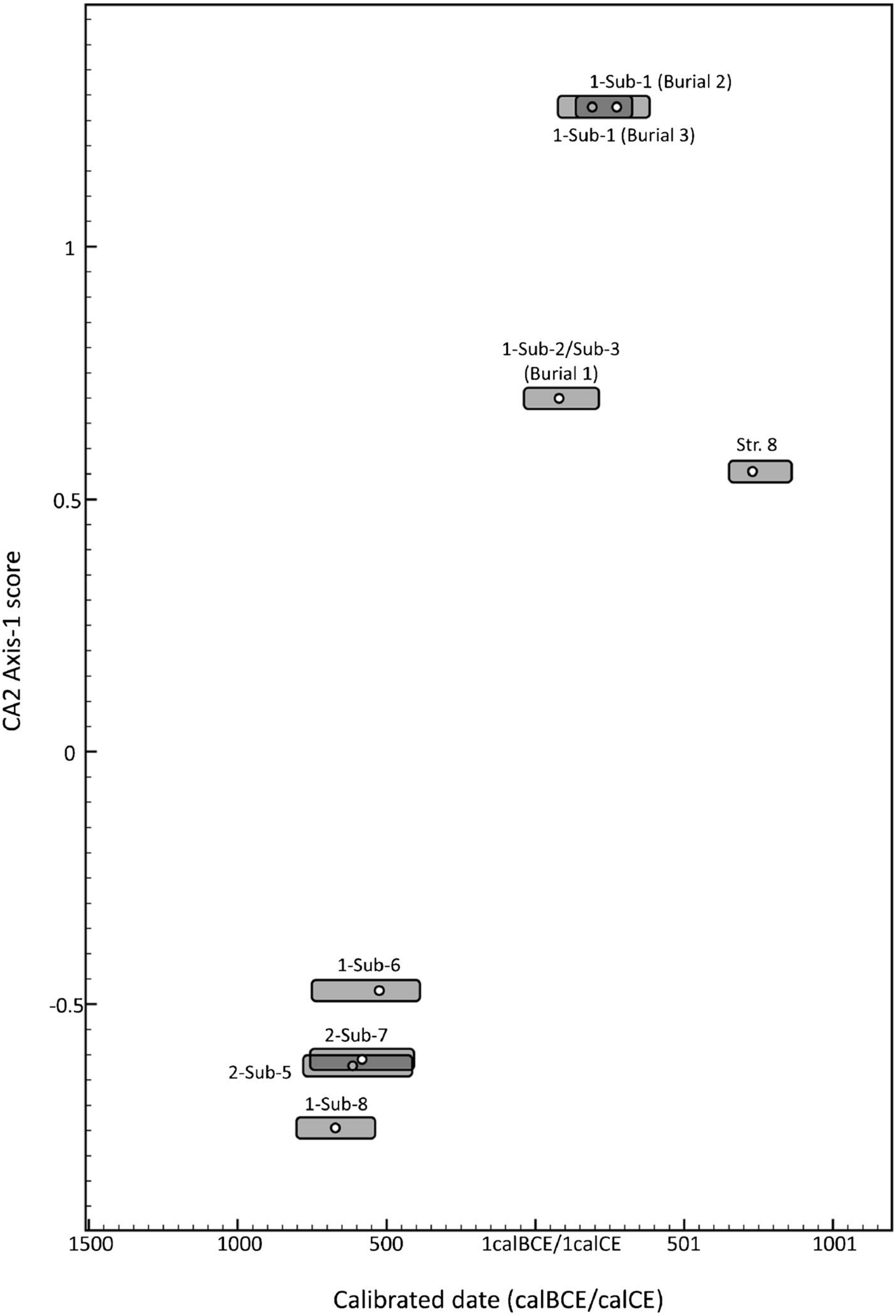

Fig. 7 Plot of the calibrated date ranges relative to the first axis resulting from the second CA (with assemblage 2-Sub-8 excluded). Note the degree of overlap in radiometric determinations dated between 800 and 500 BCE

reconstruct the chronological sequence of these building events—which invariably involve multiple dimensions of these processes—then, it makes sense that we should consider a broader collection of objects, artifacts, and noncultural indicators in our analyses of past construction practices.

This analysis proposes that assemblages defined as "contemporaneous" solely on the basis of temporally sensitive ceramic artifacts may be further classified according to their morphological and compositional similarity. This approach suggests that by including additional variables which account for the deposit's matrix and composition, finer resolution of these depositional practices may be achieved. The assumption here is that deposits with similar matrix and compositional attributes (*e.g.*, artifact density, species diversity, percentage clay/plaster) are more likely to have formed under similar social and historical circumstances in much the same way that stylistic attributes are argued to covary. For the construction of Preclassic Maya architecture, this assumption may not be farfetched. Scavenging refuse for construction purposes is closely related to factors of availability and demand, which are themselves influenced by patterns of settlement growth and decline (Schiffer 1987, p. 109).[8] Thus, when demand for building materials is high, we would expect to find deposits containing diverse assemblages of refuse and other scavenged materials. If the construction of two buildings co-occurs during periods of settlement growth and expansion, we would further expect these deposits to have similar matrix and compositional attributes. Such data may thus provide important information for separating and identifying underlying spatiotemporal structure of deposits composed of primary and secondary refuse material. It should be emphasized that this approach is not necessarily equivalent to identifying activity areas because we are seeking to identify similarity among deposits that may contain high content diversity. To measure these patterns of similarity, cluster analysis can be employed as another commonly used multivariate classification technique in archaeology.

Although correspondence analysis is a preferred method for making comparisons between archaeological assemblages (Baxter 2003, pp. 136–146), other multivariate techniques such as cluster analysis may hold an advantage for their ability to handle a variety of different cases and variables, thus allowing greater flexibility for the inclusion of diverse datasets and multiple lines of evidence. Cluster analysis similarly operates on a two-way contingency table, but decomposition of the data matrix is achieved by creating a similarity or distance matrix, which can then be displayed in a variety of ways. These proximity matrices can be generated using different measures, and analysts are commonly cautioned to justify their selection of measures or evaluate multiple models because different measures may produce different results (Aldenderfer and Blashfield 1984, pp. 14–19). In some cases, however, this problem

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[8] Note, however, that this assumption may not hold for all archaeological contexts. Such scavenging behavior may be unique to Maya construction practices as noted by Schiffer (1987, p. 111). In other cases, archaeologists may benefit from more detailed studies of artifact wear, sherd size, or calculating the proportion of rim/body sherds to determine patterns of deposition and reuse as suggested by one reviewer. Qualitative assessments of sherd size and surface preservation are noted in the ceramic analysis, although these observations were not translated into quantifiable measures for the purpose of this analysis. Rather, the objective here is to gain a broad understanding of the degree to which procurement practices (whether contemporaneous or using the same source) are reflected in the archaeological record using a more complete characterization of these architectural deposits with a wider array of variables.

is minimized due to measurement constraints of the variables and data types included in the analysis. There exist several excellent descriptions of cluster analysis written for archaeology (Aldenderfer and Blashfield 1984; Baxter 1994, 2003; Shennan 1997), and a recent text by Everitt *et al.* (2011) provides a detailed mathematical discussion of this method along with new algorithms for nonparametric tests that provide an independent test of significance used in this study.

Sampling and Clustering Results

The assemblages included in this analysis were restricted to those assigned to the Preclassic group represented in the second CA (see Fig. 6). This subsample not only represents the period of greatest construction activity at Caobal but is also the phase of greatest chronological uncertainty. Given the assumption that deposits composed of a similar matrix are more likely to have formed under similar spatiotemporal conditions, it is important to minimize potential confounding effects due to formation processes and the mixing of old material into later deposits. Thus, deposits from lower levels, such as those in the Preclassic group, or those that may have formed very rapidly, should perform better in this kind of analysis.

Several variables were identified as being important characteristics of deposit composition and these are listed in Table 4. These variables were selected on the basis that they may better represent the cumulative actions associated with each construction event, including the selection and preparation of primary building materials, identification of resources (*i.e.*, middens) for secondary fill material, and activities either directly or indirectly related to these construction events. The primary artifact classes found in these deposits (ceramics, chert, obsidian) are included as continuous variables and normalized according to the volume of construction fill in each deposit. Rather than just relying on simple counts of these artifacts, this standardization procedure ensures comparability across assemblages regardless of the actual deposit size. Of the species of fauna identified, mollusks overwhelmingly dominate assemblages at Caobal (Munson 2012, pp. 464–469), and are therefore also included. The majority of these specimens were mostly intact, suggesting that consumption and primary deposition of mollusks may have occurred in close association with the building events. The final two variables reflect the presence of shaped stone and

Table 4 Selected variables included in the cluster analysis to characterize deposit composition. The continuous variables were standardized according to the volume of construction fill in each assemblage to make unbiased comparisons between assemblages

Variables	Unit	Data type
Ceramic density	kg/m^3	Continuous
Chert density	kg/m^3	Continuous
Obsidian density	kg/m^3	Continuous
Mollusk NISP	Relative frequency	Ordinal
Marl/plaster	Presence/absence	Binary
Stone architecture	Presence/absence	Binary

lime-based construction materials, which should aid in separating earthen-based construction techniques from other building methods within the same phase.

Cluster analysis includes a variety of methods for partitioning data into groups based on some measure of similarity or distance. This study used the data analysis software package PAST because it can accommodate a dataset with multiple data types, including up to twenty different indices to compute the distance matrix, and because it includes a non-parametric multivariate analysis of variance (NPMANOVA) test to assess the significance of clusters (Hammer et al. 2001). One output of the NPMANOVA test is a pairwise comparison between clusters that provides the necessary justification for making empirically relevant analogical statements about the assemblages. In this study, a hierarchical agglomerative method called unweighted pair-group method was used to form the clusters. In this approach, also known as group average linkage, clusters are joined based on the average distance between all members in the two groups (Everitt *et al.* 2011, p. 76). It is described as a relatively robust method that tends to join clusters with small variances (Everitt *et al.* 2011, p. 79). In the case of mixed data types, this algorithm uses a weighted combination of similarity and distance measures specific to each data type (Hammer 2012, p. 44). For this analysis, two models were compared using different sets of standard measures available for mixed data types (Table 5). Gower is the standard distance measure used for continuous and ordinal data and averages the difference over all variables with each term being normalized for the range of that variable (Everitt *et al.* 2011, pp. 54–56). Bray–Curtis is another similarity index commonly used in ecology to measure abundance data (Hammer 2012, p. 42). The Jaccard coefficient provides a standard measure for presence–absence data where joint presences are meaningful (Everitt *et al.* 2011, pp. 46–47). In addition, a constraining methodology was applied to retain the spatial relationships within excavation units—a common technique in situations where stratigraphic context is primary (Everitt et al. 2011, pp. 237–242; Kovach 1993). Finally, a nonparametric test of significant difference between clusters was conducted, which provides a pairwise comparison between all pairs of assemblages with corrected *p* values (Anderson 2001).

The dendrograms in Figs. 8 and 9 illustrate the consistent results obtained from both cluster models using the input variables described above and the Preclassic assemblages identified in the second CA (see Fig. 6). Each model identifies the same number of clusters above the 0.4 similarity index and group membership within these clusters is replicated across both models. Each group contains deposits from multiple excavated

Table 5 Model parameters and comparative results for each cluster analysis

Model	Similarity measure	Coph. Corr.	NPMANOVA *F* statistic
1	Gower (continuous, ordinal) Jaccard (binary)	0.6918	10.79 (p=0.0001)
2	Bray–Curtis (continuous) Gower (ordinal) Jaccard (binary)	0.674	7.377 (p=0.0001)

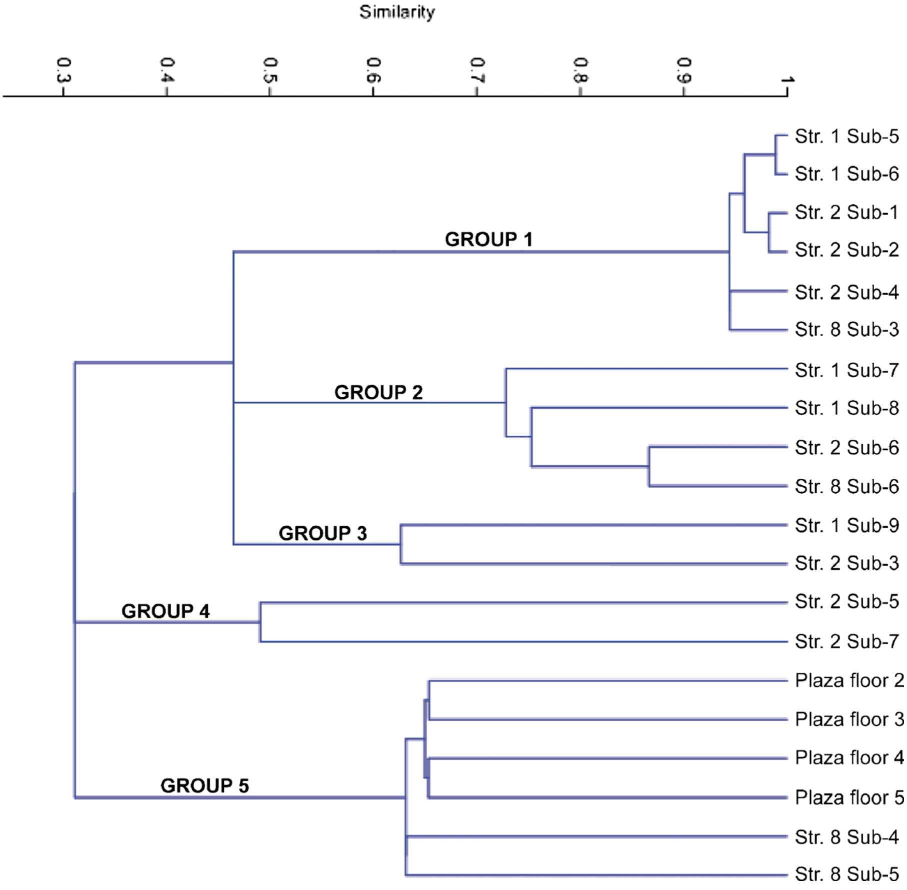

Fig. 8 Dendrogram from the cluster analysis of model 1. Groups 1, 2, and 5 are significantly different from one another based on pairwise comparisons of the clusters (see Table 6)

contexts at Caobal, thus accounting for spatial variability in the composition of these assemblages and interpretation of synchronic episodes of construction across the site. Results of the NPMANOVA indicate that three of the groups were significantly different from one another and can be reliably described as distinct clusters (Table 6). These groups are discussed in further detail below. Although the remaining groups may not be distinct in terms of their compositional makeup, these deposits can be placed in the overall construction sequence based on their stratigraphic position relative to the significant groups.

Intersecting Dimensions of Architectural Practice

Results of the cluster analysis identified three distinct and significant sets of deposits that help refine the sequence of platform and monumental construction at the site of Caobal. These groups, defined on the basis of deposit composition, provide the empirical support to make linkages between the layering and accumulation of architectural deposits as well

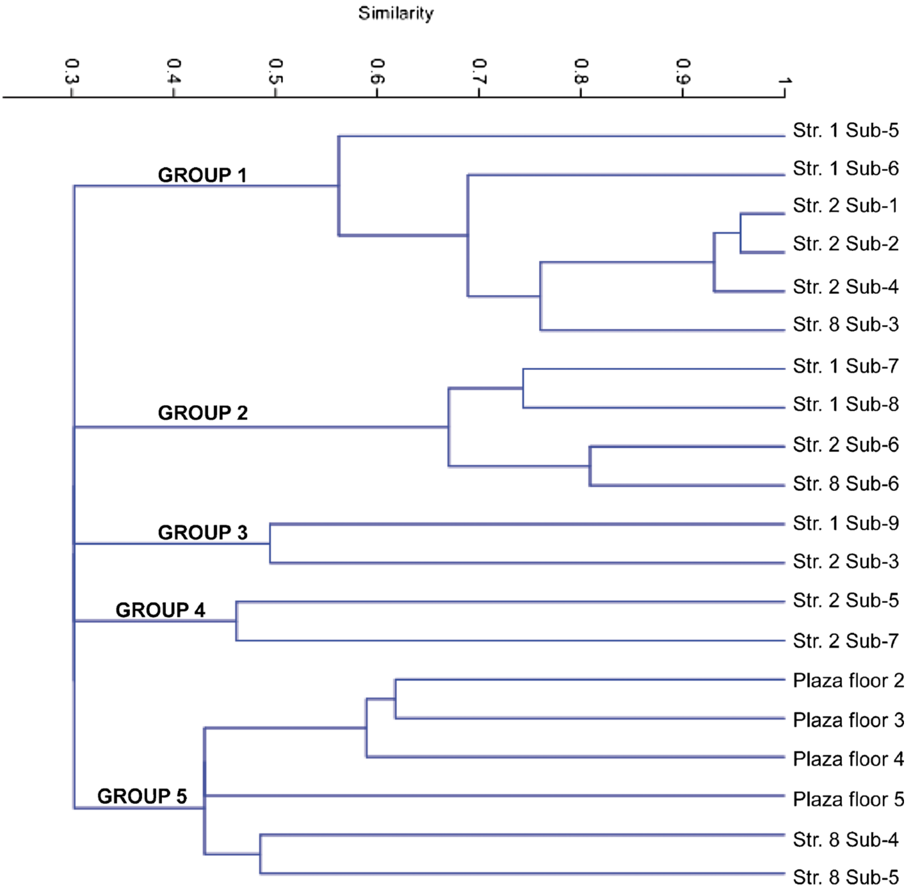

Fig. 9 Dendrogram from the cluster analysis of model 2. Groups 1, 2, and 5 are significantly different from one another based on pairwise comparisons of the clusters (see Table 6)

as the human social networks that contributed to their construction. While results from the correspondence analysis were unable to distinguish within-phase episodes of construction based solely on ceramic content and radiometric determinations, the additional variables used in the cluster analysis enable finer separation of the Preclassic construction sequence and recognition of spatial coherence of building practices across the site. Assemblages within each of the three groups were constructed using similar techniques and materials, and are thus likely to have been deposited under comparable social and historical circumstances. As discussed in further detail, the stratigraphic consistency between groups further supports the interpretation of the assemblages' internal synchronicity. This information can be combined with the course-grained results from correspondence analysis and radiometric determinations to refine the sequence of architectural practices across spatial and temporal domains as well as estimate the timing and rates of these building events (Fig. 10).

Group 1 includes assemblages from three different excavation loci at Caobal (Op. AN1A, AN1B, AN1D). These assemblages (1-Sub-6, 1-Sub-5, 2-Sub-4, 2-Sub-2, 2-

Table 6 Pairwise cluster comparisons measured by the ratio of the *F* statistic. The larger the value of *F*, the more likely it is that the null hypothesis of no difference among the group means is false. Significance was computed using Bonferroni-corrected *p* values and significant values are shown in italics ($p<0.05$). Italicized values indicate significance

	Group 1	Group 2	Group 3	Group 4
Model 1				
Group 2	*43.65*			
Group 3	5.48	6.87		
Group 4	24.03	7.01	4.21	
Group 5	*9.09*	*13.55*	1.92	10.31
Model 2				
Group 2	*24.71*			
Group 3	4.438	8.195		
Group 4	9.682	3.515	3.013	
Group 5	*7.514*	*10.45*	1.518	5.584

Sub-1, and 8-Sub-3) are grouped together based on their use of plaster and contained relatively little refuse in the construction fill. Despite the low density of ceramic content in these deposits, radiometric and ceramic cross-dating suggests these architectural levels were constructed between 530 BCE and 250 CE. The two earliest assemblages from Structures 1 and 2 in this group likely correspond to the Middle to Late Preclassic transition, which is the beginning of a period of population increase and settlement expansion across the southern Maya lowlands (Ringle 1999; Sharer 2006, pp. 231–250). These two assemblages also represent significant investments in monumental platform construction as well as the transition from earthen to plaster-based construction techniques—patterns that follow similar architectural trends at other Preclassic Maya sites (Munson 2012, pp. 82–87). This set of assemblages is defined by compositional similarities between deposits from discrete loci. While this information provides some basis to infer that similar practices were responsible for the deposition of these materials, it does not mean that they all correlate to the same event. Rather, we can use this information to reliably distinguish this set of construction episodes from those assigned to different groups, and then use the stratigraphic and radiometric data to determine the chronological ordering between groups.

The assemblages described above can be distinguished from other Preclassic assemblages assigned to Group 2 based on the use of clay and abundant organic refuse. These architectural deposits include construction fill from some of Caobal's earliest occupations including 1-Sub-8, 1-Sub-7, 2-Sub-6, and 8-Sub-6. The architectural style of these structures is consistent in that they represent a series of low earthen platforms raised with low stone walls and are filled with dense concentrations of primary and secondary refuse such as broken ceramic vessels, chipped stone artifacts, faunal remains, and large quantities of mollusk shell. Again, these construction practices are consistent with settlement patterns at other Middle Preclassic villages, including nearby Ceibal. Stratigraphically, this set of assemblages precedes those in Group 1, so that the transition from clay-based to plaster construction techniques is apparent. While this transition is clearly distinct in the individual

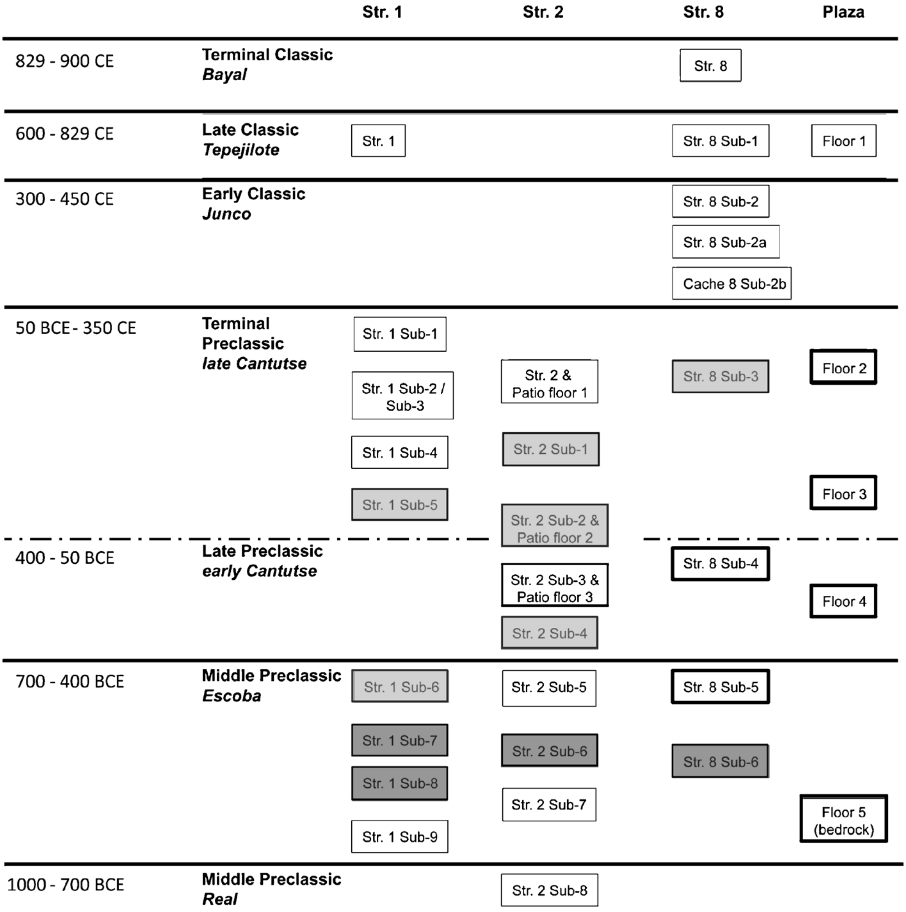

Fig. 10 Construction sequence for excavated contexts in Caobal's temple precinct. *Light gray units* are contexts assigned to group 1 based on the cluster analysis results. *Dark gray units* were assigned to group 2 and *heavy black outlined units* from Str. 8 and Plaza contexts were assigned to group 3 according to results of the cluster analysis. Other assemblages were ordered based on stratigraphic position and assigned phases based on ceramic analysis and radiometric determinations

building profiles, these results allow us to see how this architectural transformation unfolded across the site.

The third set of assemblages represents architectural surfaces such as plaza and patio floors, which presumably were formed via a different process than the building platforms described above. These levels make up Group 5 and correspond to plaza floors 2, 3, and 4, as well as 8-Sub-5 and 8-Sub-4, which appear to be extensions of the plaza area made prior to the construction of any raised architecture beneath Structure 8. Unlike the heavy investment in plaza floor construction at Ceibal (Inomata et al. 2013), the plaza area at Caobal may have been periodically swept clean but no formal surface seems to have been constructed. Rather, these surfaces may have formed as an indirect accumulation of debris and periodic cleaning. Although there is no apparent temporal signature to this third group, the assemblages in this cluster may distinguish unintentional acts of strata formation from more direct architectural practices within Caobal's temple precinct.

In combination with the chronological overview obtained from CA, these groups of similar architectural deposits provide a solid basis for interpreting specific social and material practices from Caobal's long stratigraphic record. In particular, Groups 1 and 2 help refine the sequence of construction within the temple precinct during the Preclassic period. Although the ceramic material does not provide the temporal resolution to distinguish these episodes of construction, systematic characterization of the deposits' content allows us to identify similar practices and spatiotemporal variations in construction technology and selection of specific construction materials. This evidence can now be effectively incorporated into detailed and reliable narratives that detail the sequence of social and architectural practices that contributed to Caobal's long settlement history (Munson 2012). Rather than recount this narrative description, I conclude by returning to the broader objectives of this paper to discuss how this methodological exercise strengthens practice-based interpretations of archaeological stratigraphy.

Summary

Results of the preceding analyses provide the necessary evidence to reconstruct the history of repeated practices that contributed to the construction and physical transformation of multiple buildings in Caobal's temple precinct. As this sequence illustrates, this modest ceremonial center was not permanent in the sense of being built once and left to endure nor were these static architecture features on the landscape. Ancient built environments were dynamic entities (Stanton and Magnoni 2008), as were the social relationships that connected people to these places and the ties between communities. For Preclassic Caobal, we see how this community repeatedly integrated ceremonial architecture in their social landscape. Although we know very little about the earliest settlers at Caobal, they established a permanent community and were committed to constructing monumental architecture from a very early stage. The juxtaposition of domestic refuse in the fill of nonsecular structures points to the collective participation, communal character, and perhaps rapid manner in which these early mounds were built. The transformation of this local center into a more circumscribed and formal ceremonial space was achieved through the expansion and plastering of earthen structures. The varied rates and construction techniques of adding on to and building over earlier structures reflects the series of actions, practices, and relations in which archaeologists interpret the “webs of human interaction” that created such built environments. However, in order to develop explanations of how past people actively constructed, maintained, modified, and transformed their social and material worlds, it is essential to analyze the cross-cutting domains of architectural practice in terms of these spatial and temporal components.

This paper argues that interpreting the interconnected social consequences of depositional practices requires analyzing broader spatiotemporal contexts and patterning of layered architectural deposits. The analyses outlined in this paper emphasize the intersection of these domains in a rigorous empirical framework. By analyzing artifact patterning alongside the composition of sediments in which they are found, this study illustrates how the materiality of architectural deposits represent a complex arrangement of objects that occupy space and time in quite variable ways. In particular, the findings of this study identify similarities in the ways past people constructed their built environments and supports interpretations about the social practices that sustained Preclassic communities such as Caobal. The basic methodological approach outlined in this paper is particularly promising for studying the tradition of monumental architecture in Mesoamerica, given its duration and repeated sequences of construction. Following a Peircean semiotic approach, finding the connection and area of overlap between such indexical properties allows us to build strong linking arguments between accumulation and networking processes (Knappett 2011, pp. 165–168). However, the empirical linkages and the methodology that underpins these connections demonstrate just one of many ways to operationalize relational metaphors in archaeology.

Interpretations based on these empirical relationships demonstrate how archaeologists can begin to apply metaphorical notions of networks, webs, bundles, relations, and entanglements in a more scientific framework. While the methodological approach outlined in this paper hints at the potential strength of social network analysis and related methods as a body of techniques for transforming this metaphor, more archaeological studies are needed to evaluate the effectiveness of specific ordination or clustering analyses, particularly those based on contingency tables (Munson and Pinzón n.d.). It should be clear that the incorporation of such techniques does not replace the interpretative objectives of practice theory approaches in archaeology. Rather, this set of theoretically disembodied analyses directly complements existing network metaphors as well as the social and material practices that define them. Without developing methods that build on the expectations of these metaphors, archaeological inferences may lack interpretative value. Connecting formal empirical analyses to these heuristic concepts holds the promise of strengthening archaeological understanding of connected past worlds and bridging a path between humanistic and scientific understandings of networks and relationality.

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