Quaternary Science Reviews 173 (2017) 211–235

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Regional response to drought during the formation and decline of Preclassic Maya societies

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ARTICLE INFO

Article history:
Received 22 November 2016
Received in revised form
19 June 2017

Keywords:
Radiocarbon dating
Bayesian chronological modeling
Paleoclimatology
Central America
Preclassic Maya
Social complexity

ABSTRACT

The earliest complex societies and a distinctive set of pan-regional social, political, and economic institutions appeared in the southern Maya lowlands during the Preclassic period (ca. 1200/1100 cal BCE–cal 300 CE). The timing of these cultural changes was variably influenced by local developments, interaction with other regions of Mesoamerica, and climate change. We present a high-resolution radiocarbon chronology for the growth of the early polity of Cahal Pech, Belize, one of the first permanent settlements in the southern Maya lowlands. We compare our results to a database containing over 1190 radiocarbon dates from cultural contexts reported from five major regions of the southern lowlands to interpret the expansion and decline of emerging complex social groups during the Preclassic. Comparisons to paleoclimate proxy datasets suggest that fluctuating climate regimes may have promoted alternating integration and fragmentation of early hierarchically organized societies. Stable climatic conditions during the Middle Preclassic (1000/900-300 cal BCE) fostered the centralization of populations and the formation of large regional polities across the southern lowlands. An extended drought at the end of the Late Preclassic (cal 150–300 CE) likely contributed to the decline of some major polities in the central Petén, but smaller sites located in productive environments were more resilient and persisted in to the Classic period. This research provides a framework for understanding the complex social and environmental factors that influenced localized adaptations to climate change and the episodic growth and decline of early complex societies in prehistory.

1. Introduction

The questions of when, why, and how hierarchical societies emerge, grow, and disintegrate, and why some were more resilient than others have been topics of archaeological research for decades (Kintigh et al., 2014). The development of the earliest complex prehistoric societies was a long-term and dynamic process driven by various cultural and environmental factors. Complex societies, characterized by institutionalized social and economic inequality, developed in the context of population aggregation along with new forms of management and production of subsistence resources, control of labor, and control of economically important goods by leaders. These activities resulted in the formation of multi-level economic, social, and political networks between groups, allowing paramount centers to become central nodes within increasingly interconnected socio-political systems (Cowgill, 2012; Earle, 1987, 2002; Flannery, 1999; Turchin, 2003; Willey, 1991). The resilience of early complex societies was challenged by endogenous and exogenous factors, frequently resulting in the fragmentation of paramount polities and sometimes the development of completely new social systems (Carneiro, 1970; Wright, 1994; Steward, 1955:51). This type of socio-political cycling has been documented in multiple regions of the world in prehistoric and historic contexts including the Near East (Wright, 1994; Wright and Johnson, 1975), Europe (Shennan et al., 2013), Mesoamerica (Marcus, 1993, 1998, 2012; Smith, 1992), eastern North America (Anderson, 1996), and the Southwest US (Bocinsky et al., 2016).

Increasing emphasis has been placed on examining the role of

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http://dx.doi.org/10.1016/j.quascirev.2017.08.020
0277-3791/

coupled socio-natural systems in the historical dynamics related to the emergence and disintegration of complex societies in the past (de Menocal, 2001; Dillehay and Kolata, 2004; Kennett and Marwan, 2015; Rosen and Rivera-Collazo, 2012; Gavrilets et al., 2010). Archaeologists working in the southern Maya lowlands of Mexico, Guatemala, Belize, and Honduras have drawn from several sources to build models that define cycles of socio-political organizational change during the later Classic and Postclassic (~250–1500 CE) periods. Most notably, Marcus (1993, 1998) developed the "dynamic model" based primarily on glyphic texts recording dynastic histories, political alliances, and conflicts between divine kings from several lowland polities (see also Martin and Grube, 2008; Schele and Freidel, 1990). Under the dynamic model, Classic Maya prehistory is characterized by a series of recurring peaks and valleys between cal 250–900/1000 CE, which correspond to the centralization and decentralization of political systems, as well as to broad-scale regional variability in social integration and complexity. During two prominent peaks in the cycle (400–550 CE and 600–800 CE) elite dynasties located at paramount centers (e.g., Tikal, Calakmul, Caracol, Naranjo) were territorially extensive with multi-tiered settlement hierarchies. The expansion of these sites is coincident with a period of high precipitation recorded in regional paleoclimate records (Douglas et al., 2016b; Kennett et al., 2012; Hodell et al., 2005; Medina-Elizalde et al., 2010), which favored stable environmental conditions and fostered agricultural production, population expansion, and aggregation. Valleys in the cycle often correspond with periods of climatic stress. During the Terminal Classic period, paleoclimate data document numerous severe multi-decadal droughts occurring between cal 820–1100 CE, which likely influenced several waves of societal collapse, first in the southern lowlands and then in the northern lowlands of the Yucatán Peninsula (Akers et al., 2016; Curtis et al., 1996; Douglas et al., 2015; Haug et al., 2003; Hodell et al., 1995, 2005; Hoggarth et al., 2016; Kennett et al., 2012; Medina-Elizalde et al., 2010).

Significant cycles of social and political development also occurred earlier in the Maya lowlands during the Preclassic period (~1200/1000 cal BCE-cal 350 CE; Table 1). This period represents one of the most critical transitions in Maya prehistory, when the development of sedentary village life, increased reliance on maize agriculture, and the adoption of ceramic technology first appeared. These developments occurred several centuries earlier in other regions of Mesoamerica, and the details of the processes influencing the later adoption of sedentary farming lifestyles in different regions of the Maya lowlands remain unresolved (Clark and Cheetham, 2002; Lohse, 2010). By the Late Preclassic, however, archaeological data indicates that Maya society had become complex and hierarchically organized, with centralized polities serving as focal points for civic and ritual activity (Chase and Chase, 2012:259; Estrada-Belli, 2011; Schele and Freidel, 1990; Hansen et al., 2002; Inomata et al., 2017; Stanton, 2012; Stanton and Ardren, 2005). The appearance of monumental architecture and development of long-distance exchange networks during this time also signal the formation of an elite class that centralized wealth and power in the region (Doyle, 2017; Estrada-Belli, 2011). Paleoclimate research has indicated that the expansion and contraction of Preclassic Maya society was influenced in part by environmental factors. Particular attention has been paid to an extended period of drought at the end of the Late Preclassic (~cal 100–300 CE), which has been linked to population decline and abandonment of some major lowland centers, as well as a hiatus in construction activity in some parts of the southern lowlands (Haug et al., 2003; Dunning et al., 2014; Medina-Elizalde et al., 2016; Webster, 2002).

Table 1
Lowland Maya chronological periods.

Time Period	Calibrated Date Span
Colonial	1519–1821 CE
Postclassic	900/1000–1500 CE
Terminal Classic	800–900/1000 CE
Late Classic	600–800 CE
Early Classic	250/300–600 CE
Late Preclassic	300 BCE–250/300 CE
Middle Preclassic	1000–300 BCE
Early Preclassic	1200–1000 BCE

In this paper, we examine the cultural and climatic context for the development of Cahal Pech, an important Preclassic regional center located in the Belize Valley of modern-day Belize (Fig. 1). Cahal Pech provides a case study for understanding the origins and development of prehistoric lowland Maya society because it has a long occupational history beginning first in the Early Preclassic (~1200-1000 cal BCE) and ending during the Terminal Classic period (cal 850–900/1000 CE). We developed a high-resolution Bayesian radiocarbon chronology to understand the timing and tempo of development within the Cahal Pech civic-ceremonial site core, and for the residential settlement surrounding the center. We then compare the Cahal Pech chronology to a larger dataset of published radiocarbon dated cultural contexts ($n = 1196$) within the Belize Valley and other major regions of the southern Maya lowlands. Bayesian radiocarbon chronological models and summed probability distributions were created for five core regions of the lowlands in order to clarify the timing of localized Early through Late Preclassic social, political, and economic developments in relation to regional paleoclimate records. The results of this study serve to clarify long-term trends in socio-political dynamics at the local and regional levels in the southern Maya lowlands, and help to interpret the role of climate change as one possible mechanism for cultural evolution during the Preclassic. Constraining the timing of cultural change in relation to past climate change has implications for understanding long-term global social and environmental developments in both the past and the future.

2. Background

2.1. Preclassic climate regimes

Archaeological and paleoclimate studies have highlighted variability in human responses to environmental change as a potential factor in the episodic expansion and breakdown of prehistoric and modern societies (Axtell et al., 2002; Brenner et al., 2002; Haug et al., 2003; Dillehay and Kolata, 2004; Douglas et al., 2016a,b; Hoggarth et al., 2016; Iannone, 2014; Kennett et al., 2012; Kennett and Marwan, 2015; Ridley et al., 2015). In the Maya region, the first comprehensive paleoclimate proxy studies from lake sediment records in northern Yucatán showed temporal variations in sedimentation rates and evaporation and precipitation records based on oxygen isotopes ($\delta^{18}O$) of ostracods and gastropods, which correspond to multi-decadal dry episodes from the Preclassic through Postclassic periods (Hodell et al., 1995, 2005; Curtis et al., 1996; Rosenmeier et al., 2002). These drought events correlate closely with broader climate histories from the circum-Caribbean recorded in the Cariaco Basin sediment Ti record, especially during the Terminal Classic when the most severe and protracted droughts likely influenced the Classic Maya "collapse" (Haug et al., 2003).

More recently, high-resolution speleothem records from both the northern and southern lowlands have supported the hypothesis that multi-decadal droughts played a role in several waves of socio-political disintegration between cal 850–1100 CE (Akers et al.,