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CLIMATE-CHANGE STUDIES IN THE MAYA AREA

A diachronic analysis

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Abstract

The series of papers on climate change published in this issue are the result of the symposium "Environmental Change in Mesoamerica: Physical Forces and Cultural Paradigms in the Preclassic to Postclassic," held at the 63rd Annual Meeting of the Society for American Archaeology in March 2000 in Philadelphia. The authors bring their expertise in paleoclimatological studies to bear on the Maya Lowlands and Highlands from the beginning of the Holocene to the Postclassic and modern times. The studies reveal that climate has changed during the past 4,000 years to a considerable degree that correlates in a reasonable way with archaeological periodizations. Several climate-change models are presented as an effort to understand better past cultural and natural events.

The articles about climate change in the Maya area in this and the forthcoming issue were presented at a symposium held at the 63rd Annual Meeting of the Society for Archaeology, held in Philadelphia in March 2000. The symposium, "Environmental Change in Mesoamerica: Physical Forces and Cultural Paradigms in the Preclassic to Postclassic," was organized by Ray T. Matheny, Joel D. Gunn, and William J. Folan because of the interest generated by numerous articles about climate proxy indicators in the Maya area published in journals not widely read by archaeologists. Most of those articles were written by paleoclimatologists and other specialists who had shifted the focus of their studies to the Maya area and who relied on Mayanists to help them understand the cultural implications of their studies.

In the past, some Mesoamerican archaeologists and other scholars, as is described later in this paper, tried to develop models to understand past climate change in the area. However, few Mayanists have considered climate change as a force that played a significant role in affecting the course of ancient Maya society. Jeremy Sabloff (1973:37) correctly noted that the effects of climatic change "are difficult to prove because the hypothesized events leave little or no tangible archaeological remains." In the years since Sabloff made this statement, considerable advances have been made in studies of paleoclimatology and paleoecology. Such studies in the Maya area are producing information and results that are important to Mayanists, and they must be able to understand and evaluate these data for the implications to their own studies.

Attempting to merge or correlate data from archaeology and these other sources often causes confusion, in part because of the different approaches that archaeology and other disciplines take. The data that archaeologists study are carefully accumulated from surveys and excavations, generally over long periods, and include various categories relating to past human behavior. Although these data reflect an incomplete picture of past behavior, archaeologists have reached considerable consensus in a number of areas, including the chronology and periodization of Maya culture, which are supported by suites of radiocarbon dates and cross-dating techniques. Paleoclimatological data, by contrast, are based on studies of phenomena (e.g., pollen and charcoal from lake sediments, paleolimnological specimens, river-discharge information, volcanic activity, Andean ice cores, and El Niño events) that usually result in general rather than specific correlations with traditional archaeological evidence (see Rice 1996).

Despite the difficulties of correlation with archaeological data, it is clear the paleoclimatological studies are producing information and hypotheses about past climates that archaeologists must consider. Just as archaeologists learned to incorporate the data made available by the advancing decipherment of Maya hieroglyphic writing, they must also make use of the data made available by paleoclimatological studies to inform their studies of ancient Maya civilization. It is now suggested that climatic processes played a significant role in the cultural changes that occurred in at least some parts of the Maya area from the Preclassic to Early Classic, Early Classic to Late Classic, and Late Classic to Postclassic periods. In particular, a number of studies suggest that the decline of Maya civilization in the Terminal Classic period was greatly influenced, if not caused, by a prolonged drought. For many archaeologists, these ideas smack of cultural determinism and raise the concerns that have been associated with such concepts in the history of anthropology. This caution is justified given the lack of control investigators have over materials from the past and the uncertainty introduced by the methods of study. Often we simply do not know how the Maya responded to the many variables of their environment. Technological and other innovations are the central elements of adaptation to changing environmental situations. Indeed, some anthropologists emphasize that culture is an adaptive mechanism and because it is objects a culture leaves for us to ponder, interpretation is often channeled to them. Bruce Dahlin (1983), for example, considers how the northern Maya's strategies of adaptation to the prolonged Terminal Classic drought may have allowed them to flourish while the southern and central Maya areas collapsed.

Attempting to integrate paleoclimatological data into our picture of ancient Maya civilization as perceived in broad terms can be hazardous to one's credibility. Maya civilization is an abstract concept created by 150 years of study, and there is a sense among some scholars that we understand very well the basic details of its development and demise. Paleoclimatological studies provide new information and hypotheses that challenge our comfortable understanding of Maya civilization. We should not be afraid to test these new data and concepts. But we must remember that many of the data are new, and caution is advised until further testing has been done.

In this introduction we provide a brief overview of the history of paleoclimatological studies in the Maya area. We show that the exigencies under which the Maya civilization developed and ultimately failed in the ninth century were a phenomenon of global perspective (Bluemle et al. 1999; Folan, Gunn, Eaton, and Patch 1983).

PRE-HISPANIC MESOAMERICA: A GLOBAL PERSPECTIVE

Anyone who has lived and worked in the Maya Lowlands for extended periods is keenly aware of a great difference between the wet and dry seasons. More subtle are the year-to-year changes in wetness and dryness. Even so, one is aware that, in any given year, certain *aguadas* are dry and in the next year the same *aguadas* will fill to overflowing (Gunn et al. 1995). As one is directly affected by these year-to-year differences, it becomes obvious that there is a range of annual wetness and dryness. These differences occur not only on a yearly basis; at times they extend as droughts lasting several years or even decades. Sometimes they strike one part of the Yucatan Peninsula or highlands but not others. Thus, climatic differences occur through space and time at a number of scales.

Other phenomena accompany multiyear episodes of drought and wetness. Some years are memorable for forest fires in Quintana Roo and the Campechan and Guatemalan Peten. Some droughts bring great swarms of seemingly indestructible locusts. In the countryside, locusts consume milpa crops by preference but also invade cities, leaving ornamental plants devoid of foliage. Some droughts are marked by long cold spells. This affects the flowering of most plants and the distribution of their pollen.

In contrast to manifestations of drought, an occasional year will pass with no dry season at all. Instead, intermittent showers will occur during the usually dry months of March, April, and May.

Scientists have attempted to describe and understand, or model, differences among climates in the Maya Lowlands for more than 100 years. In this article, we briefly review the development of these efforts. We divide the modeling into two approaches: retrospective and prospective (Gunn and Folan 2001). The retrospective-modeling approach attempts to use physical evidence from the past to understand the relationship between climate and culture change. The processes of climate change seldom play a role in these models. Prospective models are based on processes. They generally engage patterns on a global or regional scale that can be used to define a chain of causation from global or areal processes to local processes. Because processes are in a sense timeless, the results of prospective models can be extended into both the past and the future or transferred from place-to-place. Most important, they can be joined with models of local cultural processes to enlarge our understanding of why cultures are as they are, or were.

RETROSPECTIVE MODELS

Ancient and historical records, both anecdotal and data-based, can be used in retrospective models. Droughts as well as excessively wet periods were registered in the Maya records of the Chilam Balams (Folan and Hyde 1985) and early Colonial histories (Folan, Gunn, Eaton, and Patch 1983). At times, droughts were responsible for the death of up to 50% of the indigenous population (Fariss 1984), even during historic times, when great quantities of grain could be imported by ship from the United States. Fray Diego de Landa (1941 [1566]), a long-time resident of northern Yucatan in the sixteenth century, reported that much of the armed conflict among the Maya was caused by a scarcity of water. He makes note of good and bad climatic periods that occurred before and after the arrival of his Spanish predecessors. Landa said that drought and famine had led to stealing. This provoked the taking of slaves, which in turn precipitated warfare. As a result of famine, Maya towns were abandoned. Later nineteenth-century writings, such as those of Eligio Ancona (1978–1979) and Juan Francisco Molina Solis (1904–1913) reiterated some of Landa's earlier observations. Early Maya and Hispanic writers and early explorers such as John Lloyd Stephens (1963 [1843]) documented a mid-nineteenth-century drought.

Early climatologists, including Ellsworth Huntington (1913, 1945) and C. P. E. Brooks (1970), were interested in the Maya past and present. Unfortunately, their racial opinions and geographic determinism not only overshadowed the value of their more astute paleoclimatic observations; it relegated their work to obscurity for a great many scholars. Otherwise, subsequent investigators might have considered climatic change as an important factor in a more complete understanding of the ancient Maya.

As unfortunate as Huntington's racist bias was, it is paralleled in impact by the assumption of climatic uniformity made by John Page (1933). He implied without adequate data that no record for climatic change existed in the Maya Lowlands after A.D. 600, when (according to him) the Itza arrived on the Yucatan Peninsula. This statement was acceptable to many archaeologists, as it provided a record of environmental stability within which an archaeological chronology could be established, while ignoring the widely consulted paleoclimatic records published up to that time. Others, perhaps, did not wish to risk being classified as "cultural determinists."

In spite of the tendencies evident in the 1930s and 1940s, eminent scholars pursued understanding of climate changes on a worldwide basis. Ernst Antevs (1948) published a climate sequence for the North Atlantic area in the 1940s. Mesoamericanists likewise began to search for local connections to global phenomena. James Robert Morarity (1967) offered a climatic record for Central America in which he summarized existing knowledge of global climate, especially distinctions between glacial and non-glacial periods,

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and speculated on the effects these changes had on the Maya Lowlands. Pedro Armillas (1964) and later John Whiting, John Sodergran, and Stephen Stigler (1982), described a movable frontier in northern Mexico and the southern United States that varied from north to south according to global climatic fluctuations (Folan 1987). Not to be forgotten is Enrique Florescano's (1969) paper on climate change and the price of corn and its influence on the Mexican revolution of the early twentieth century.

The advent of serious, empirically based climate studies in the Maya Lowlands began in the 1970s with Alan Covich and Minze Stuiver (1974) using isotope studies of freshwater-snail shells in a northern Yucatan lake that indicated climate change. This was followed by Dahlin and Foss (Dahlin, Foss, and Chambers 1980; Dahlin 1983), who worked with soils from El Mirador, in the Department of Peten, Guatemala. Through analysis of the soil profiles, they attributed El Mirador's demise to a severe drought around A.D. 250. Their analysis matched well with archaeological evidence for the collapse of the Late Preclassic at the site (Matheny 1986). These and several other paleoecological studies (Deevey 1969; Deevey et al. 1979; Leyden 1987; Vaughan et al. 1985; Wiseman 1985) prompted many scholars to be more aware of climate as a powerful player in the field of Maya archaeology, especially if it was not associated with the Maya collapse.

Soon to appear was an article by Joel Gunn and Richard Adams (1981) offering a retrospective model of Mesoamerican climate change and associated observations of the development and decline of several Mesoamerican cities. The article used a large network of precipitation and temperature observations across North and South America to understand differences in location and intensity of moisture based on assumptions about the relationships between global temperatures and local rainfall. Although largely a retrospective model, it presaged, in these later processes, the prospective models soon to follow.

PROSPECTIVE MODELS

Prospective models began to appear in the 1980s. After reading a pre-publication version of the Gunn and Adams article, William Folan devised what we believe to be the first fully recognizable prospective model of Lowland Maya climate- and culture-change processes. This article (Folan 1981; Folan, Gunn, Eaton, and Patch 1983) utilized data sensitive to global temperatures, Arctic tree rings prepared by George Denton and Wibjörn Karlén (1973:Figure 1), and solar emissions by John Eddy (1977:88). These data were coupled with areal precipitation-generating forces such as the double-sea-breeze effect developed by J. Aaron Williams (1976) from satellite observations of daily cloud movements in the wet season and interannual dislocation of the Bermuda-Azores Subtropical High. Although both of the latter phenomena are set in the context of movements of the intertropical convergence zone (Haug et al. 2001), they explain more precisely changes in the local precipitation regime. The cloud movements were used to explain the shift of the tropical/subtropical ecotone across the peninsula with changes in global temperatures. The analysis brought into play the global forces paralleling cultural events such as the Maya Collapse. These globally based processes began to explain the differences between drought and wet years in an informed context that assisted understanding of the Maya Collapse. The results led Folan (1981); Folan, Gunn, Eaton and Patch (1983); and Folan, Kintz, and Fletcher (1983) to suggest that Maya civilization, as confirmed by David Hodell, Jason Curtis, and Mark Brenner (1995), collapsed because of drought during the ninth century A.D.

As in the Collapse example, explaining the reason for interannual differences provides an overview from which archaeologists can understand and extrapolate the effects of climate change and co-model them with cultural processes. For example, Folan, Gunn, Eaton, and Patch (1983) emphasized the coordinated effects of sea-level change in the Gulf of Mexico coasts and atmospheric changes. At one time, the forces of the sea and atmosphere might have been regarded as separate effects. It is now understood that they are both secondary effects of changing global average temperature. As the world warms, the sea level rises from the melting of glacial ice, and storms in the atmosphere are likewise linked, though in a more complex fashion (Gunn et al. 1994, 1995). These changes were responsible for shifting adaptations in coastal regions through processes such as the inundation of a Florescent-period building off the coast of Campeche (Eaton and Ball 1978). Similar events were later associated with a now-underwater *sacbe* and defensive wall associated with Isla Cerritos off the coast of northern Yucatan (Folan 1987), excavated and otherwise interpreted by Anthony Andrews and Tomás Gallareta (1986).

In the early 1980s and 1990s, the articles by Gunn and Adams (1981) and Folan, Gunn, Eaton, and Patch (1983) provided the underpinnings for additional prospective-modeling efforts. The authors undertook studies in the local modern climate of the western Yucatan Peninsula (Folan et al. 1992) and into the local agricultural practices that were adapted to these conditions. The result of these studies appeared in 1994 in a prospective model that identified the links between global climate and regional agricultural practices (Gunn et al. 1994, 1995). Continuing precepts of the earlier studies, local climates were measured against solar, volcanic, and atmospheric variations. Local conditions were measured through the discharge of the Candelaria River system in Campeche and northern Guatemala. The resulting prospective model was projected mathematically back in time and into the future. It correctly evoked both the droughts of A.D. 250 proposed by Dahlin (Dahlin 1983; Dahlin, Foss, and Chambers 1980) and the A.D. 800 drought proposed by Folan (Folan, Gunn, Eaton, and Patch 1983; Folan, Kintz, and Fletcher 1983) to be associated with the Maya Collapse. A lake-bottom core from Quintana Roo (Hodell et al. 1995) supported aspects of the Candelaria River model for some droughts and not for others. As we shall see, however, regional variations appear to be significant, and the Candelaria River and the Quintana Roo core are on opposite sides of the Yucatan Peninsula.

Also in the 1990s, Richardson Gill (1994, 2000) analyzed atmospheric-pressure data on the movements of the Bermuda-Azores Subtropical High relative to the global average temperatures. This study showed that the high moved with changes in global temperatures, as Ronald Neilson (1986) had proposed earlier from studies of North American grasslands. Gill's finding was important because such movements were used by Gill (1994, 2000); Folan, Kintz, and Fletcher (1983); and Gunn et al. (1994, 1995) as a process to explain the variations in rainfall from year to year based on interannual movement in the boundary between the tropical and subtropical zones across the Yucatan Peninsula: Southward movement means dry, and northward means wet, conditions. This finding is one of the key explanations of why interannual rainfall varies and why modern *milperos* and ancient civilizations appear to coordinate their activities to the drumbeat of global climate.

At the beginning of the new millennium, the authors (Gunn and Folan 2001) extended prospective principles to three river basins in the western Yucatan Peninsula: the Champoton, Candelaria, and the Usumacinta rivers. This article showed that year-to-year differences in climate are themselves highly variable from region-to-region. For example, the Candelaria River discharge is highly sensitive to variation in solar emissions, while the Champoton River discharge is more affected by the El Niño. Discharge from the Usamacinta River is not aligned with either of these external sources of variation; rather, it has its own internal variations. Thus, whether archaeologists work at Palenque, Calakmul, Champoton (Folan et al. 2001), Edzna, or Tikal (Robichaux 2000), they must pay attention to a local prospective model of climate and cultural interaction to understand the relationships between them.

Extensive field research in Coba from 1974 to 1976 led Folan, Kintz, and Fletcher (1983) to conclude that this very important, central place in Quintana Roo collapsed due to drought, a finding that was later supported by investigations in Lake Chicancanab, Yucatan (Hodell et al. 1995). Furthering these studies, Hodell and colleagues (Hodell et al. 2001) have detected recurrent droughts through solar emissions. The model was developed out of a restudy of lake sediments in Quintana Roo that provided a higher-resolution understanding of the environment there. The solar-emissions process underlies, with other variables, the successful projection of past climate in the Candelaria watershed (Gunn et al. 1995). The Hodell et al. (2001) study suggests that a 208-year solar cycle influences droughts. Perhaps this cyclicity is related to Dennis Puleston's (1979) hypothesis that the Maya had discovered a predicable 256-year, 13 *katun* cycle, which they used to guide calendrical components of their society.

CONCLUSIONS

The course that prospective models will take will depend on the needs of regional archaeologists for defining past climate–culture relationships and on the needs of policymakers and the global-change-study community to understand the nature of local climate change in the future.

Several features of prospective models address these needs in an open-ended fashion:

1. By joining prospective models of climate change with local processes, one can explain why certain conditions appear in some regions and not in others. The Champoton watershed, for example, is too small to reflect influences from solar emissions so notable in the Candelaria drainage.
2. By addressing the processual interactions of climate and culture, prospective models make it possible to tease out understanding of local cultural sequences. For example, deforestation of the upper Champoton valley creates flooding in the lower Champoton valley. This explains why large cities flourished in the upper and lower valley at different times.

An important component of prospective modeling will be the means by which cultures incorporate long-term knowledge of climate into their daily routine and repertoire of behavior. A study now being conducted by Joel Gunn and Betty Faust suggests that this is done through calendrical ceremonies.

RESUMEN

Esta serie de estudios sobre cambios climaticos publicados en este numero de Ancient Mesoamerica representa el resultado de un simposium titulado "Environmental Change in Mesoamerica: Physical Forces and Cultural Paradigms in the Preclassic to Postclassic" llevado acabo en la 63° reunión anual de la Society for American Archaeology en Philadelphia, en marzo de 2000. Los autores traen la habilidad de sus conocimientos en estudios sobre la paleoclimatología para ejercerlos sobre las tierras bajas y altas de los mayas antiguos desde el principio del Holoceno hasta el postclásico y los tiempos modernos. Estos estudios revelan que el clima ha cambiado durante los ultimos 4,000 años en un grado considerable que se correlaciona de una manera razonable con periodicidad arqueológica. Se presentan varios modelos de cambios culturales y climatologicos como un esfuerzo para entendar mejor los acontecimientos culturales y naturales del pasado.

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