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The Mayans: Climate Determinism or Geomagnetic Determinism?

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Climatic variations since the end of the last ice age have been large enough to influence the fate of ancient civilizations, and deciphering the exact role of climate in the history of old societies is an active and challenging domain of research [e.g., *deMenocal,* 2001]. This potential influence, which serves as the foundation of 'climate determinism,' can be viewed as the response of natural-resource-dependent, agriculture-based communities to climatically driven environmental changes. In some cases, these could have provoked major damage in economic and social organization of the societies, thus paving the way for political disintegration.

Could this climate variability be connected with the Earth's magnetic field? If so, a link might be found between the past geomagnetic field behavior and the history of humanity. This article explores that potential link, using a case study of the Classic Maya civilization.

Recent Research on the Relationship Between Climate and Maya History

In recent years, the history of the Classic Maya civilization, which flourished in the Yucatan Peninsula (Meso-America) during the first millennium A.D., has become one of the best documented examples for a direct causal link between climate change and the collapse of a complex society [*Hodell et al.,* 1995; *Curtis et al.,* 1996; *Haug et al.,* 2003]. Climate in the Maya region is controlled by the seasonal latitudinal migration of a belt of heavy precipitation, called the Intertropical Convergence Zone (ITCZ). Most of the rain falls during the summer and fall when the ITCZ is located over Yucatan; the climate is dry during the winter and spring when the ITCZ migrates over the equator or farther south.

Several studies have described the vulnerability of the Maya civilization to water availability. In the northern part of the Yucatan Peninsula, sink holes give access to shallow groundwater, while the hydrologic system around Petén Lake in central Yucatan provides a large freshwater reservoir. In contrast, the water budget to the west and south of Yucatan is mostly dependent on rainfall because groundwater is less accessible and water reservoirs are scarcer [e.g., *Haug et al.,* 2003]. During the Classic Maya civilization, the latter two zones were highly cultivated and densely populated, which made agricultural production sensitive to prolonged droughts with the risk of large-scale famines.

A rather large set of petrologic and isotopic data obtained from sediment cores recovered from northern Yucatan lakes and from the marine Cariaco Basin, north of the Venezuelan coast, revealed the occurrence of several late Holocene periods of drier conditions and recurrent droughts [e.g., *Hodell et al.,* 1995; *Curtis et al.,* 1996; *Haug et al.,* 2003]. One of them is clearly defined between approximately A.D. 750 and 900 at the time of the disintegration of the Classic Maya civilization. Within a century and a half, most Mayan urban centers were permanently abandoned, with the southern lowlands of Yucatan in particular having suffered a demographic disaster.

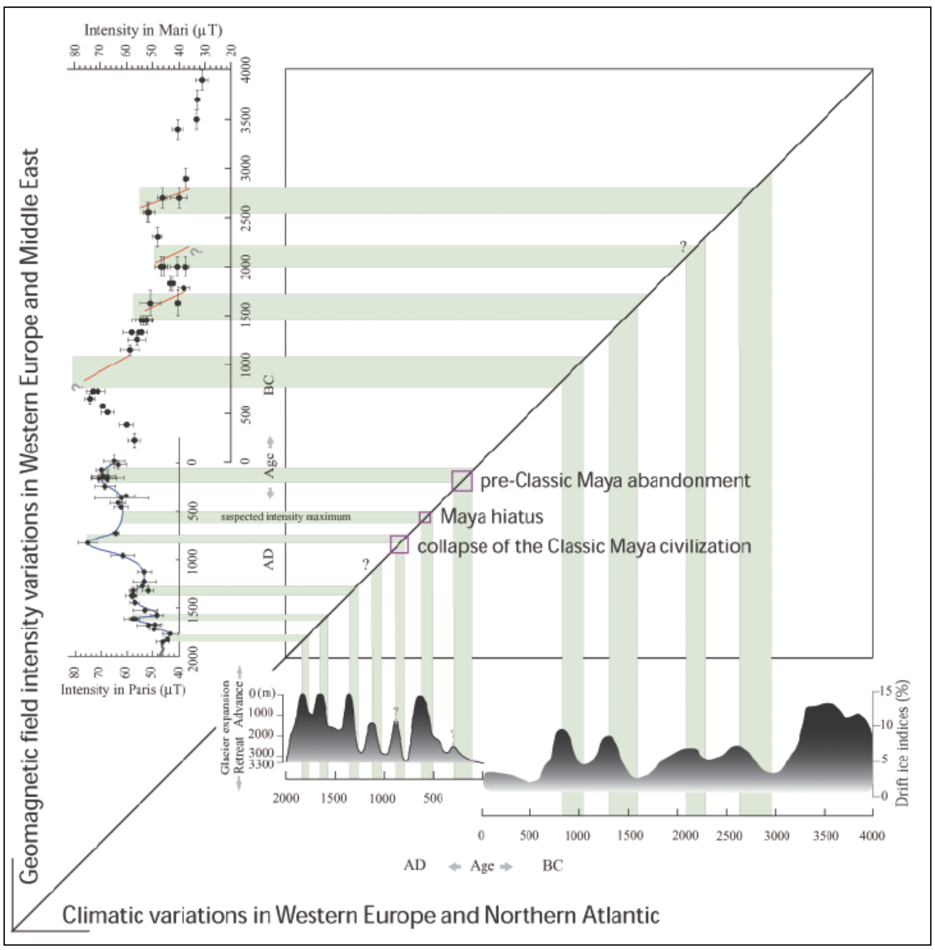

Fig. 1. Geomagnetic field intensity variations obtained from France and the Middle East plotted against climatic fluctuations in the eastern North Atlantic. An overall good temporal coincidence is observed between periods of geomagnetic field intensity increases (horizontal bands) and cooling events (vertical bands), the latter being marked by glacier advances on land and increases in ice-rafted debris in deep-sea sediments. The three main discontinuities in the history of the Classic Maya civilization are indicated by purple boxes.

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Settlements remained only in the regions with stable water supplies.

In fact, the seasonal migration of the ITCZ and its associated rainfall pattern most probably played a critical role over the whole Maya history. Another severe drought appears synchronous with the pre–Classic Maya abandonment between approximately A.D. 150 and 250, which was marked by the desertion of major cities [*Haug et al.,* 2003]. A period of stagnation around A.D. 600, called the Maya hiatus, may have been caused by unfavorable climatic conditions as well [*Curtis et al.,* 1996], whereas the following century was wetter, which probably allowed the rapid expansion of the Maya civilization.

Thanks to global teleconnections among regional climates [e.g., *Mayewski et al.,* 2004], climate variability in the North Atlantic and in western Europe may also give insight into the relationship between climate and Maya history. Climate in these regions is well documented by a large data set, including the proportion of ice-rafted debris in marine sediments [*Bond et al.,* 2001] and glacier expansion on land. Temporal fluctuations of the lengths of Swiss glaciers led *Holzhauser et al.* [2005] to identify several colder periods at approximately 1000–600 B.C. and approximately A.D. 500–600, 800–900, 1100–1200, and 1300–1800, all synchronous with high lake levels in eastern France. Although less well quantified, the Great Aletsch glacier also advanced during the Roman period, which correlates with a distinct rise in lake level at approximately A.D. 150–250. Together, these data indicate a succession of three cooling periods in western Europe during the first millennium A.D. Their ages are remarkably coincident with those of the main discontinuities in the history of Maya civilization (Figure 1). A causal link can be understood because an increase in the sea surface temperature gradient between the North Atlantic and the tropical Atlantic may have resulted in a southward shift of the mean latitudinal position of the ITCZ [e.g., *Haug et al.,* 2001], thus reducing summer-fall precipitation over the Yucatan Peninsula.

The example of the Maya above, and similar data from ancient civilizations in Mesopotamia and the eastern Mediterranean, do not imply that all abrupt societal downturns were directly caused by climatically induced environmental changes. Different factors including interhuman relations and human activities (deforestation or overgrazing) that damage the natural environment may also have pushed societies to their ends. The demise of well-organized civilizations was undoubtedly the result of complex processes combining different causes where climate forcing may have sometimes played the role of a catalyst. In semiarid regions (the Middle East) or in seasonal desert (Meso-America) where old societies were critically dependent on water supply, and thus particularly vulnerable to precipitation, a climatic trend toward drier conditions was likely efficient to destabilize those societies.

Possible Geomagnetic Influence on Climate

Holocene climatic variability has been attributed to long-term fluctuations in solar activity. However, this interpretation remains debatable because the connection between solar activity proxies and climate change may not be univocal [e.g., *Legrand et al.,* 1990].

Recently, *Gallet et al.* [2005] emphasized the good temporal coincidence in western Europe between cooling events recovered from successive advances of Swiss glaciers over the past 3000 years and periods of rapid increases in geomagnetic field intensity (Figure 1). The latter are nearly coeval with abrupt changes, or hairpin turns, in magnetic field direction. They suggested a causal link between these geomagnetic features, called archeomagnetic jerks, and climate change over multidecadal timescales. This is because variations in morphology of the Earth's magnetic field could have modulated the cosmic ray flux interacting with the atmosphere, modifying the nucleation rate of clouds and thus the albedo and Earth surface temperatures [*Gallet et al.,* 2005; *Courtillot et al.,* 2007]. *Gallet et al.* [2006] further proposed that four archeomagnetic jerks occurred between 3000 and 0 B.C. in western Eurasia, whose ages appear either coincident with, or close to, the ages of North Atlantic cooling events.

At present, the archeomagnetic data set does not allow one to make a definitive choice between a dipolar (i.e., a sporadic dipole tilt toward lower latitudes) or nondipolar origin for the archeomagnetic jerks. Whichever the case, though, the most plausible mechanism linking geomagnetic field and climate remains a geomagnetic impact on cloud cover. Regarding the first millennium A.D., archeointensity data obtained from Meso-America are scarce and do not permit the recovery of the geomagnetic field variations with a sufficient time resolution. Those from France are also limited, but less, yet they allow one to propose two archeomagnetic jerks, the first around A.D. 200 and the second at approximately A.D. 800. More recently, *Gallet et al.* [2005] discussed the possibility for another archeomagnetic jerk at approximately A.D. 600 based on directional variations (cusp). No French intensity data are currently available for this event. Only results from Bulgaria show a succession of two intensity peaks during the second half of the first millennium A.D. that may confirm its existence [*Kovacheva,* 1997].

Hypothesis of 'Geomagnetic Determinism'

Three archeomagnetic jerks may have occurred in western Eurasia during the first millennium A.D. that coincide within age uncertainties with cooling periods at high to middle latitudes in the North Atlantic region, drier events over the Yucatan Peninsula, and Maya crises. This situation is reminiscent of the coincidence, previously mentioned by *Gallet et al.* [2006], between archeomagnetic jerks, cooling periods in the North Atlantic, and aridity episodes in the Middle East during the last three millennia B.C., which are synchronous with several societal changes in Mesopotamia and the eastern Mediterranean. A causal link may therefore exist between geomagnetic behavior on one side, and decadal/multidecadal climatic variations responsible for some major societal events on the other.

Our study leads us to propose the idea of a 'geomagnetic determinism' in the history of humanity. Although not yet demonstrated, principally because of the presently limited archeomagnetic data set, we hope that this idea will motivate data acquisition and thorough dialogue between researchers involved in archeomagnetism, internal/external geomagnetism, paleoclimatology, cloud/solar physics, and archeology.

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