Evidence of a Medieval Warm Period in North America:

South of the United States

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EVIDENCE OF A MEDIEVAL WARM PERIOD IN NORTH AMERICA: SOUTH OF THE UNITED STATES

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Climate alarmists claim that rising atmospheric CO_2 concentrations due to the burning of fossil fuels - such as coal, gas and oil - have raised global air temperatures to their highest level in the past one to two millennia. And, therefore, investigating the possibility of the existence of a period of equal or greater global warmth within the past one to two thousand years has become a high-priority enterprise; for if such a period could be shown to have existed at times when the atmosphere's CO_2 concentration was *far* less than it is today, there would be no compelling reason to attribute the warmth of our day to the CO_2 released to the air by mankind's burning of the fossil fuels that supplied the power that sustained the Industrial Revolution. Therefore, in this review of the pertinent scientific literature, results of the search for such knowledge are presented for studies conducted within North American countries located south of the southern border of the United States.

> The correspondence between warm medieval temperatures and dry hydrologic anomalies in Panama supports a large-scale Medieval Climatic Anomaly that may have been global in extent, and involved atmospheric circulation reorganizations that are linked to ENSO.

Lachniet *et al.* (2004)[1] generated a high-resolution oxygen-isotope rainfall record of the Central American Monsoon for the Isthmus of Panama from a U/Th-dated stalagmite that spanned the period 180 BC to AD 1310. The data derived therefrom revealed pronounced hydrologic anomalies during medieval times, with the driest conditions occurring between AD 900 and 1310, but especially during the AD 1100-1200 "High Medieval," when western European temperatures were reported, in their words, to be "anomalously high." And in further commenting on their findings, the seven scientists stated that "the correspondence between warm medieval temperatures and dry hydrologic anomalies in Panama supports a large-scale Medieval Climatic Anomaly that may have been global in extent, and involved atmospheric circulation reorganizations that are linked to ENSO." And it almost goes without saying that such reorganizations of earth's climate system have historically *not* been dependent on rising atmospheric CO_2 concentrations to trigger them; and, therefore, it

[1] http://www.co2science.org/articles/V8/N1/C3.php.

logically follows that the development of the Current Warm Period likely was largely unrelated to the concomitant increase in the air's CO_2 concentration, being forced instead by a return engagement of whatever it was that led to the development of the Medieval Warm Period.

A decade earlier, based on a single sediment core retrieved in 1993 from Lake Chichanacanab in the center of the northern Yucatan Peninsula of Mexico (19°50'-19°57'N, 88°45'-88°46'W), Hodell *et al*. (1995) provided evidence for a protracted drought during the Terminal Classic Period of Mayan civilization (AD 800-1000), while subsequently, based on two additional sediment cores retrieved from the same location in 2000, Hodell *et al*. (2001) determined that the massive drought likely occurred in two distinct phases (750-875 and 1000-1075). And later still, Hodell *et al*. (2005)[2] returned to Lake Chichanacanab in March of 2004 and retrieved a number of additional sediment cores in some of the deeper parts in the lake, with multiple cores being taken from its deepest point.

Depth profiles of bulk density data were then obtained by means of gamma-ray attenuation, as were profiles of reflected red, green and blue light via a digital color line-scan camera. And in the words of the researchers who did the work, "the data revealed in great detail the climatic events that comprised the Terminal Classic Drought and coincided with the demise of Classic Maya civilization," while also revealing that "the Terminal Classic Drought was not a single, two-century-long megadrought, but rather consisted of a series of dry events separated by intervening periods of relatively moister conditions," which "included an early phase (ca 770-870) and late phase (ca 920-1100)." Last of all, they reported that "the bipartite drought history inferred from Chichancanab is supported by oxygen isotope records from nearby Punta Laguna," and that "the general pattern is also consistent with findings from the Cariaco Basin off northern Venezuela (Haug *et al*., 2003), suggesting that the Terminal Classic Drought was a widespread phenomenon and not limited to north-central Yucatan." And so it would indeed appear that the Terminal Classic Drought that led to the demise of Mayan civilization likely occurred during the climatic transition between the Dark Ages Cold Period and the Medieval Warm Period, *when increasing temperatures may have exacerbated land water loss via evaporation in the midst of a prolonged period of significantly reduced precipitation*.

Near simultaneously, Almeida-Lenero *et al*. (2005)[3] analyzed pollen profiles derived from sediment cores retrieved from Lake Zempoala (19°03'N, 99°18'W) and nearby Lake Quila (19°04'N, 99°19'W) in the central Mexican highlands about 65 km southwest of Mexico City. And in doing so, they determined it was generally more humid than at present in the central Mexican highlands during the mid-Holocene. Thereafter, however, there was a gradual drying of the climate; and their data from Lake Zempoala indicated that (1) "the interval from 1300 to 1100 cal yr BP was driest and represents an extreme since the mid-Holocene," and that (2) this interval of 200 years "coincides with the collapse of the Maya civilization." Likewise, they reported that their data from Lake Quila were also "indicative of the most arid period reported during the middle to late Holocene from c. 1300 to 1100 cal yr BP." In addition, they indicated that "climatic aridity during this time was also noted by Metcalfe *et al*. (1991) for the Lerma Basin [central Mexico]," that "dry climatic conditions were also reported from Lake Patzcuaro,

[2] http://www.co2science.org/articles/V8/N51/C2.php.
[3] http://www.co2science.org/articles/V8/N50/C2.php.

central Mexico by Watts and Bradbury (1982)," and that "dry conditions were also reported for [Mexico's] Zacapu Basin (Metcalfe, 1995) and for [Mexico's] Yucatan Peninsula (Curtis *et al*., 1996, 1998; Hodell *et al*., 1995, 2001)." And so it would indeed appear that some of the driest conditions of the Late Holocene throughout much of Mexico may have occurred during the climatic transition between the Dark Ages Cold Period and the Medieval Warm Period, when again, *increasing temperatures may have exacerbated land water loss via evaporation in the midst of a prolonged period of significantly reduced precipitation*.

Two years later, Barron and Bukry (2007)[4] analyzed high-resolution records of diatoms and silicoflagellate assemblages spanning the past 2000 years that were derived from sediment cores extracted from three sites on the eastern slope of the Gulf of California, comprising core BAM80 E-17 retrieved at 27.92°N, 111.61°W; core NH01-21 retrieved at 26°17.39'N, 109°55.24'W, and core NH01-26 retrieved at 24°16.78'N, 108°11.65W. And in all three of these cores, the relative abundance of *Azpeitia nodulifera* (a tropical diatom whose presence suggests the occurrence of higher sea surface temperatures), was found to be far greater during the Medieval Warm Period than at any other time over the 2000-year period studied, while during the Current Warm Period its relative abundance was actually *lower* than the 2000-year *mean*, also in all three of the sediment cores. In addition, the first of the cores exhibited elevated *A. nodulifera* abundances from the start of the record to about AD 350, during the latter part of the Roman Warm Period, as well as between AD 1520 and 1560. And by analyzing radiocarbon production data, the two researchers found that the changes in climate they identified likely were driven by solar forcing.

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Also with a paper published in the same year were Metcalfe and Davies (2007)[5], who synthesized the findings of a variety of paleoclimate studies based on analyses of the sediment

[4] http://www.co2science.org/articles/V10/N20/C3.php.
[5] http://www.co2science.org/articles/V10/N33/C3.php.

records of several crater lakes and lakes formed by lava dams that are scattered across the Trans Mexican Volcanic Belt of central Mexico and that have an absolute chronology provided by radiocarbon dates extending back to 1500 ^{14}C yr BP. Noting that the degree of coherence among these records was "remarkable," Metcalf and Davis reported - in what was perhaps the key finding of their analysis - that "dry conditions, probably the driest of the Holocene, are recorded over the period 1400 to 800 ^{14}C yr BP (ca. AD 700-1200)," the significance of which finding was augmented by their observation that "the present day climate of central Mexico is typical of most of the country." And giving this result even *broader* significance is the fact that it is, in the words of the two researchers, "consistent with results from the Yucatan Peninsula (Hodell *et al*., 1995, 2005) … and from the Cariaco basin (Haug *et al*., 2003) and the Isthmus of Panama (Lachniet *et al*., 2004)." What is more, Mayewski *et al*. (2004) have identified the central portion of this period (AD 800 to 1000) as a time of truly *global* anomalous climate. Thus, this study provides convincing evidence that one of the strongest manifestations of the Medieval Warm Period throughout most of Mexico, and even extending beyond its borders, was *a major lack of moisture*, which in this particular part of the world better delineates the temporal realm of the Medieval Warm Period than even the epoch's primary defining characteristic of elevated temperature.

Still in the same year, Hodell *et al*. (2007)[6] inferred "the Holocene paleoclimate history of the northeastern Yucatan Peninsula by comparing physical and chemical properties in two sediment cores from Lake Punta Laguna," which is located approximately 20 km NNE of Coba. And they also discussed "the potential implications for Maya cultural transformation." More specifically, they reported that the Terminal Classic Collapse of 750-1050 A.D., which they described as "the greatest cultural discontinuity prior to Spanish contact," could "be viewed as a series of transformations, occurring first in the south during the late eighth and ninth centuries A.D., followed by a similar decline in the north in the tenth century A.D." And they also found evidence for "lower lake level and drier climate at about the same time as each major discontinuity in Maya cultural history."

The three researchers also went on to state that "the fact that both major climatic changes and cultural transformations occurred in the Terminal Classic Period between 750 and 1050 A.D. is probably not coincidental." And such is truly the case; for this time period *begins* at the *jump* in the number of worldwide studies that identify the *global* Medieval Warm Period as *beginning* in earnest at that first point in time (750 A.D.) and *culminating* within *the broader peak* of the number of studies that define the Medieval Warm Period's most common worldwide time of occurrence at approximately 1050 A.D., as shown by the Interactive Map and Time Domain Plot[7] of *co2science.org's* Medieval Warm Period Project[8]. And thus it would appear that *global* weather patterns may indeed have changed in such a way over this time period that the recurring multi-year dry spells that were characteristic of the Terminal Classic Period became ever more severe and difficult for the Maya to bear, likely leading to their collapse at the very *peak* of the global Medieval Warm Period.

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[6] http://www.co2science.org/articles/V10/N37/C2.php.
[7] http://www.co2science.org/data/timemap/mwpmap.html.
[8] http://www.co2science.org/data/mwp/mwpp.php.

Continuing the same subject thread, Polk *et al*. (2007)[9] analyzed environmental changes on Belize's Vaca Plateau via "vegetation reconstruction using $\delta^{13}C$ values of fulvic acids extracted from cave sediments," which provide "a proxy record of Maya alteration of the environment through agricultural practices," in conjunction with "speleothem carbon and oxygen isotope data from another nearby cave in the study area" that "provide information regarding climate variability."

Starting at approximately AD 500, according to the three US researchers, increasingly more negative $\delta^{13}C$ values in the sediment record indicate "the declining practice of agriculture," which they say is "characteristic of a C3-dominated environment receiving little contribution from the isotopically heavier C4 agricultural plants." This inference makes sense, because (1) the period of initial agricultural decline coincides with the well-known Maya Hiatus of AD 530 to 650, which was driven by an increasing "lack of available water resources needed to sustain agriculture," and (2) the study area "would likely have been among the first sites to be affected by aridity due to its naturally well-drained upland terrain, causing a shift away from agricultural land use that preceded [that of] many other lowland areas."

In line with this scenario, it is not at all surprising Polk *et al*. reported that, as early as AD 800, their $\delta^{13}C$ values indicated the Vaca Plateau "was no longer used for agriculture, coinciding with the Terminal Classic Collapse" of the Maya, which Hodell *et al*. (2007) identified as occurring, in total, between AD 750 and 1050. These latter figures thus indicate that the Ix Chel archaeological site on the Vaca Plateau was, indeed, one of the very first sites to say goodbye to the Maya people, as the recurring and intensifying droughts of the Medieval Warm Period gradually squeezed the life out of the Maya's waning culture.

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These discoveries of Polk *et al*. are just another example of the devastating human consequences of the catastrophic droughts that plagued many parts of North, Central and northern tropical South America during the globe-girdling Medieval Warm Period; but as such, they constitute yet another important testament to the *reality* of the Medieval Warm Period and its "globe-girdling" nature.

[9] http://www.co2science.org/articles/V10/N39/C3.php.

Finally moving ahead one year, and based on radiocarbon dating and pollen analyses of a sediment core retrieved from the shore of Naja Lake (16°59'27.6"N, 91°35'29.6"W), which is located near the Lacandon Forest Region in the state of Chiapas in southeastern Mexico, which has been inhabited by the Maya since the early Formative Period (ca. 1,000 BC), Dominguez-Vazquez and Islebe (2008)[10] derived a 2000-year history of regional drought that indicated that "a marked increase in *Pinus* pollen, together with a reduction in lower montane rain forest taxa, is interpreted as evidence for a strong, protracted drought from 1260 to 730 years BP," which they characterized as "the most severe" of the record. In fact, they wrote that "the drought coincides with the Maya classic collapse and represents the most pronounced dry period of the last 2,000 years in the Lacandon area." And, therefore, it can be appreciated that as much as the higher temperatures of the Medieval Warm Period that were experienced in Greenland benefited the Vikings, who contemporaneously colonized that part of the world, its greater dryness in southeastern Mexico cursed the indigenous Maya, who had called that region home for close to 2,000 years, indicative of the fact that millennial-scale climate change may both help and harm human societies at one and the same time, depending upon where in the world they are situated. It is also equally clear that these changes of the past occurred *independently of any changes in the air's CO_2 content*, and that if the world is in the initial stages of a "repeat performance" of the warming phase of this cycle, both positive and negative impacts can be expected once again. Consequently, the world should be preparing to capitalize upon the positives of the phenomenon and cope with its negatives, rather than trying to restrict anthropogenic CO_2

Millennial-scale climate change may both help and harm human societies at one and the same time, depending upon where in the world they are situated.

The world should be preparing to capitalize upon the positives of the phenomenon and cope with its negatives, rather than trying to restrict anthropogenic CO_2 emissions that have little to no impact on what has been a natural recurrent feature of the planet's climate throughout both glacial and interglacial periods alike.

[10] http://www.co2science.org/articles/V11/N31/C3.php.

emissions that have little to no impact on what has been a natural recurrent feature of the planet's climate throughout both glacial and interglacial periods alike.

Two years later, Escobar *et al*. (2010)[11] described how they used sediment cores from Lakes Punta Laguna, Chichancanab, and Peten Itza on the Yucatan Peninsula to "(1) investigate 'within-horizon' stable isotope variability ($\delta^{18}O$ and $\delta^{13}C$) measured on multiple, single ostracod valves and gastropod shells, (2) determine the optimum number of individuals required to infer low-frequency climate changes, and (3) evaluate the potential for using intra-sample $\delta^{18}O$ variability in ostracod and gastropod shells as a proxy measure for high-frequency climate variability." And in discussing their results, the five researchers stated that they "allow calculation of mean isotope values and thus provide a rough estimate of the low-frequency variability over the entire sediment sequence," and these results indicated that "relatively dry periods were persistently dry whereas relatively wet periods were composed of wet and dry times."

These findings, in Escobar *et al*.'s words, "confirm the interpretations of Hodell *et al*. (1995, 2007) and Curtis *et al*. (1996) that there were persistent dry climate episodes associated with the Terminal Classic Maya Period." In fact, they determined that the Terminal Classic Period from ca. AD 910 to 990 was not only the driest period in the last 3,000 years, but also a *persistently dry* period. And in further support of this interpretation, they noted that "the core section encompassing the Classic Maya collapse has the lowest sedimentation rate among all layers and the lowest oxygen isotope variability."

It should also be noted, in this regard, that the AD 910 to 990 time period falls very close to the central section of the *frequency plot* of the time-of-occurrence of the *global* Medieval Warm Period for many of the locations where it has been detected throughout the entire world, as may be seen from the Interactive Map and Time Domain Plot[12] of *co2science.org's* Medieval Warm Period Project[13], which observation suggests that the climate of the Yucatan Peninsula during that time period likely was also *persistently warm*. And that "double whammy" of *persistent warmth* and *persistent dryness* appears to have been just a bit too much for the Mayans of that trying time to endure.

Concurrently, while working in a *cienega* (a wet, marshy area where groundwater bubbles to the surface) - located at approximately 31.3°N, 109.3°W in the drainage of Black Draw Wash/Rio de San Bernardino of southeastern Arizona (USA) and northeastern Sonora (Mexico) - Brunelle *et al*. (2010)[14] collected sediments during the summers of 2004 and 2005 from the incised channel wall of the Rio de San Bernardino arroyo and the cienega surface of the San Bernardino National Wildlife Refuge, from which samples were taken, as they describe it, "for charcoal analysis to reconstruct fire history," as well as pollen data to infer something about climate. And what did they learn?

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[11] http://www.co2science.org/articles/V13/N30/C1.php.
[12] http://www.co2science.org/data/timemap/mwpmap.html.
[13] http://www.co2science.org/data/mwp/mwpp.php.
[14] http://www.co2science.org/articles/V13/N41/C2.php.

The U.S. and Mexican researchers reported that "preliminary pollen data show taxa that reflect winter-dominated precipitation [which implies summer drought] correspond to times of greater fire activity," and that the results from the fire reconstruction "show an increase in fire activity coincident with the onset of ENSO, and an increase in fire frequency during the Medieval Climate Anomaly." In fact, they write that during this latter period, from approximately AD 900 to 1260, "background charcoal reaches the highest level of the entire record and fire peaks are frequent," after which they report that "the end of the MCA shows a decline in both background charcoal and fire frequency, likely associated with the end of the MCA-related drought in western North America (Cook *et al*., 2004)." And, therefore, it would appear that the region of Brunelle *et al*.'s study is not yet as warm as it was during the MCA.

In another contemporary study, while working in the Sierra de Manantlan Biosphere Reserve (SMBR) in west-central Mexico, Figueroa-Rangel *et al*. (2010)[15] constructed a 1300-year history of the reserve's cloud forest vegetation dynamics via analyses of fossil pollen, microfossil charcoal and organic and inorganic sediment data obtained from a 96-cm core of black organic material retrieved from a small forest hollow (19°35'32"N, 104°16'56"W). This reconstruction revealed that "during intervals of aridity, cloud forest taxa tend to become reduced," while, in contrast, "during intervals of increased humidity, the cloud forest thrives." And based on these facts, the three researchers determined from their data that there was a major dry period that lasted from approximately AD 800 to 1200 in the SMBR.

The studies herein reviewed clearly demonstrate the existence of a Medieval Warm Period far removed from the stomping grounds of the Nordic Vikings, while simultaneously helping to debunk the climate-alarmist claim that the MWP was a minor non-global phenomenon.

Expounding upon this finding, Figueroa-Rangel *et al*. wrote that "results from this study corroborate the existence of a dry period from 1200 to 800 cal years BP in mountain forests of the region; in central Mexico (Metcalf and Hales, 1994; Metcalfe, 1995; Arnauld *et al*., 1997; O'Hara and Metcalfe, 1997; Almeida-Lenero *et al*., 2005; Ludlow-Wiechers *et al*., 2005; Metcalfe *et al*., 2007); lowlands of the Yucatan Peninsula (Hodell *et al*., 1995, 2001, 2005a,b) and the Cariaco Basin in Venezuela (Haug *et al*., 2003)." In addition, they said that "the causes associated to this phase of climate change have been attributed to solar activity (Hodell *et al*., 2001; Haug *et al*., 2003), changes in the latitudinal migration of the Intertropical Convergence Zone (ITCZ, Metcalfe *et al*., 2000; Hodell *et al*., 2005a,b; Berrio *et al*., 2006) and to ENSO variability (Metcalfe, 2006)." And it is also to be noted that the time frame of this significant dry period coincides extremely well with the broad central portion of the *global* Medieval Warm

[15] http://www.co2science.org/articles/V13/N41/C3.php.

Period, as may be seen by viewing the Interactive Map and Time Domain Plot[16] of *co2science.org's* Medieval Warm Period Project[17]. And this correspondence further harmonizes with the dry period's temporal association with enhanced solar activity and a southward shift of the ITCZ.

Focusing on the North American countries located south of the United States southern border, the studies herein reviewed clearly demonstrate the existence of a Medieval Warm Period far removed from the stomping grounds of the Nordic Vikings, while simultaneously helping to debunk the climate-alarmist claim that the MWP was a minor non-global phenomenon. Quite to the contrary, the MWP was truly global in extent, as demonstrated by data obtained on *all* of earth's continents; and it was characterized by temperatures that were generally *higher* than those of the recent past and present. And it did so in an atmosphere with a CO_2 concentration on the order of only 285 ppm, as compared to the 400 ppm of today.

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[16] http://www.co2science.org/data/timemap/mwpmap.html.
[17] http://www.co2science.org/data/mwp/mwpp.php.

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Cover photo of the shorline in Cancun, Mexico provided by Microsoft.