A broken climate pacemaker?—part 2

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Recent calculations have shown that the "Pacemaker of the Ice Ages" paper, by Hays, Imbrie, and Shackleton, which convinced many scientists of the seeming validity of Milankovitch climate forcing, is actually largely invalid, even by uniformitarian reckoning, due to a significant revision in the age of the Brunhes–Matuyama magnetic reversal boundary. This article asks the question, can uniformitarian scientists still make a strong argument for Milankovitch climate forcing from other paleoclimatological data sets? Although they can, and indeed often do, make a case from other data sets for some kind of Milankovitch climate forcing, uniformitarian scientists do not agree on the details of the forcing model. In other words, uniformitarian scientists seem unable to reconcile all the paleoclimate data with a single, consistent version of the Milankovitch theory. Hence, the theory is probably much weaker than generally assumed. Implications for geochronology and the debate over 'global warming' or 'climate change' are also discussed.

Milankovitch climate forcing is now the dominant secular explanation for the dozens of Pleistocene glacial intervals ('ice ages') said to have occurred within the last 2.6 Ma.[1] The Milankovitch (or astronomical) theory posits that changes in the seasonal and latitudinal distribution of sunlight, resulting from slow, gradual, variations in Earth's orbital and rotational motions, pace the Pleistocene ice ages. These changes in sunlight distribution are themselves caused by changes in the elongation of the earth's orbit (eccentricity), changes in the tilt of the earth's rotational axis (obliquity), and a combination of axial and orbital precessions (figure 1). These variations are expected to exhibit quasi-periodic cycles of about, respectively, 100, 41, and 19–23 ka. The concept of Milankovitch climate forcing has numerous problems.[2,3] In fact, these problems are serious enough that they arguably must be resolved if the theory is to survive.[4] Nevertheless, the theory is today largely accepted because of the well-known 1976 paper "Variations in the Earth's Orbit: Pacemaker of the Ice Ages".[5] The Pacemaker authors analyzed data from two southern Indian Ocean cores designated as RC11-120 and E49-18. A third core, designated V28-238, also played a major, but indirect, role in the analysis (figure 2). However, this paper is now largely invalid, even by uniformitarian reckoning, due to a significant revision in the age of the Brunhes–Matuyama magnetic reversal boundary, discussed in depth in Part 1 of this series.[6]

Ironically, uniformitarians made this age revision because they were attempting to 'tune' data within *other* sediment cores to align with Milankovitch expectations.[7,8] So uniformitarians used an age of 700 ka to help convince the world of the validity of Milankovitch climate forcing, but then revised this age to 780 ka because they were having difficulty reconciling *other* data with the Milankovitch theory! After this revision was made, it was supposedly 'confirmed' by radioisotope dating.[9] Part 1 in this series summarized the results[10–12] when the Pacemaker calculations are reperformed after taking into account this age revision.[6] It also presented a simple method whereby even non-specialists can quickly verify that the results of this iconic paper are invalid.

As an aside, it is worth noting that even after multiple extensive internet searches, I been unable to find a single, solitary candid acknowledgment in the secular literature of this serious problem with the Pacemaker results. In fact, as I show later, many uniformitarian scientists may not even be aware of the problem!

Given that there are likely hundreds of published papers that discuss the astronomical theory, one might be tempted to assume that the evidence for the astronomical theory is still very strong, despite invalidation of the Pacemaker results. However, many, if not most, of these papers simply *assume* the validity of the theory and then use that assumption to derive conclusions about geochronology or paleoclimates. However, there are at least four reasons (given below) to suspect that the astronomical theory is without a firm logical foundation.

Confirmation of the theory is difficult

First, confirmation of the astronomical theory is difficult to achieve in practice, even if one assumes 'deep time' is real. Such confirmation requires a long, undisturbed deep-sea sediment core or cores characterized by sufficiently high sedimentation rates to enable detection of the frequencies expected by Milankovitch theory. Furthermore, this core should be located in a place where the seafloor sediment data will yield the most information possible about past climate variables. The Pacemaker authors claimed that in 1976 only *two* sediment cores out of several hundred met those requirements.[13]

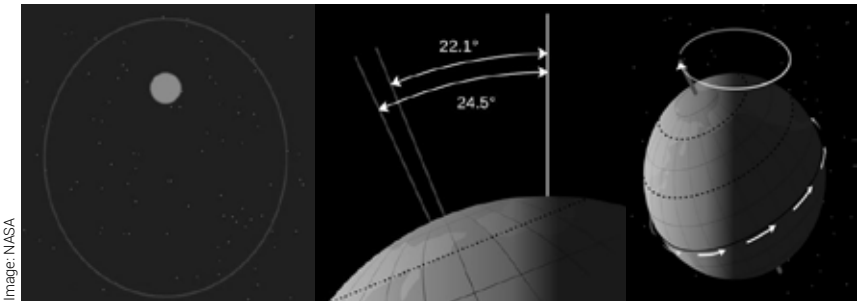

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Figure 1. The Milankovitch (or astronomical theory) posits that slow changes in the seasonal and latitudinal distribution of sunlight resulting from changes in Earth's (a) eccentricity and (b) axial tilt (or obliquity) 'pace' ice age cycles. Also contributing is the influence of axial precession (c), as it combines with orbital precession (not shown).

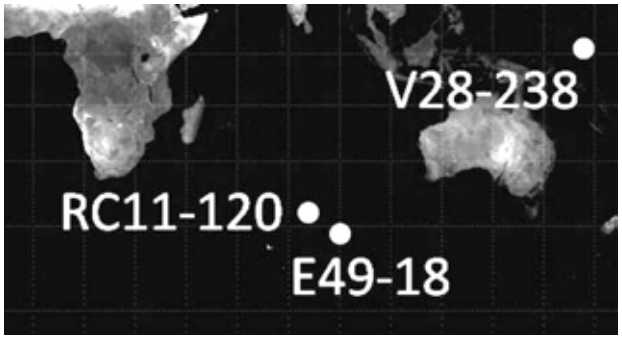

Figure 2. The "Pacemaker of the Ice Ages" paper, by Hays, Imbrie, and Shackleton, utilized data from the two southern Indian Ocean sediment cores, RC11-120 and E49-18. Another core from the equatorial western Pacific, V28-238, played an important role in establishing the timescales for the two Indian Ocean cores, particularly the longer E49-18 core.

Confirmation also requires a means of assigning tentative ages to the sediments within those cores, and this method must be independent of any implicit Milankovitch assumptions. Because radioisotope dating (within a uniformitarian framework) can only be applied to seafloor sediments in special cases (e.g. radiocarbon and uranium series dating), these timescales must be derived indirectly. The original Pacemaker paper used an assumed age of 700 ka for the Brunhes–Matuyama (B–M) magnetic reversal boundary as well as oxygen isotope ($\delta^{18}O$) data from the V28-238 western Pacific sediment core to help derive these timescales.[14,15] Because the B–M magnetic reversal was recorded at a depth of 1,200 cm within the V28-238 core, uniformitarians were able to assign ages to prominent $\delta^{18}O$ features within the V28-238 core by assuming an age of 0 ka for the top of the core and a constant sedimentation rate. These age estimates were then transferred via 'wiggle matching' to the two Indian Ocean cores used in the Pacemaker analysis. At the time of the Pacemaker paper's publication, the V28-238 core seems to have been the *only* means available to uniformitarians to assign ages to the deeper seafloor sediments.[16] In fact, the importance of the V28-238 $\delta^{18}O$ record for uniformitarian scientists is highlighted by the fact that it has been called a kind of ice age 'Rosetta Stone'.[17] But now that uniformitarians have revised the age of the B–M reversal to 780 ka, use of that very same method yields age estimates that are significantly different from those used in the Pacemaker paper. This raises the question, do uniformitarians have *another* means (independent of Milankovitch assumptions) of assigning ages to deep seafloor sediments? Do they have some *other* long, undisturbed sediment core (characterized by a nearly constant sedimentation rate) which also contains the B–M reversal boundary? And if so, have they attempted to use it to obtain revised ages for key features within the $\delta^{18}O$ record? And even if they do have it, and are now using it rather than the V28-238 core for this purpose, doesn't this seem like 'cherry picking' of dates? On what basis does one determine that one set of age estimates is more valid than another?

The prominence of the pacemaker paper

A second reason to suspect that remaining evidence for the astronomical theory is either weak or non-existent is that the Pacemaker paper is still, even today, widely cited and acknowledged as the impetus for the modern resurgence of the Milankovitch theory. If uniformitarians had a suitable 'replacement' for the Pacemaker results, one would expect that this fact would be more widely known, and that this new paper would have since overshadowed the obsolete Pacemaker paper. It is possible, of course, that many uniformitarians are simply unaware that the Pacemaker results are now invalid. For instance, this writer stated the following about the V28-238 sediment core:

> "Shackleton and Opdyke employed a different approach to date their isotope record using reversals in the Earth's magnetic field. Opdyke made systematic down-core assessments of magnetic polarity and located a reversal in V28-238 at a depth of 1,200 cm in MIS 19 (figure 3). Because the V28-238 record does not contain any obvious breaks in sedimentation, he could be confident that this was the Brunhes–Matuyama reversal—the last time the Earth's magnetic field flipped—780,000 years ago. From this fixed point ages could be interpolated for each level in the core by assuming, quite reasonably, that the sediments had accumulated at a uniform rate."[18]

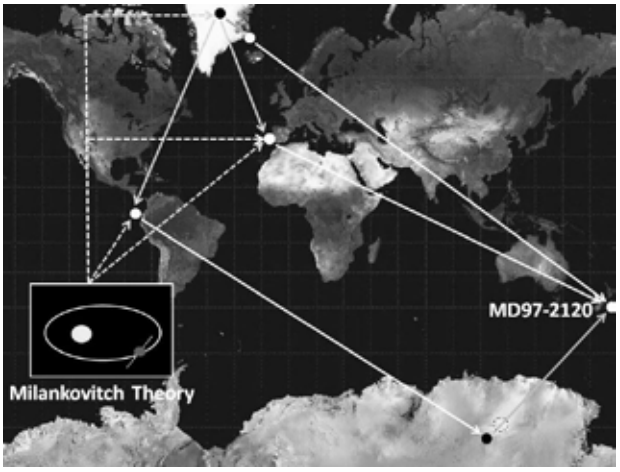

Figure 3. The age model for the New Zealand deep-sea sediment core MD97-2120 was tied to the ages assigned to other deep-sea cores and ice cores, the ages of which in turn were often tied back to the Milankovitch theory. Details are provided in references 44 and 45.

Likewise, this climate researcher made the following comment:

> "The benthic $\delta^{18}O$ ice volume record of Hays *et al*. from 1976 was one of the very first continuous records of the late Pleistocene extending back to the Brunhes-Matuyama magnetic reversal event (780,000 years ago), making it possible to construct a timescale by assuming linear accumulation rates."[19]

Both writers seem to be unaware that Shackleton and Opdyke used an age of 700 ka, rather than 780 ka, for the B-M reversal in their calculations. The confusion is understandable, as the Pacemaker paper never explicitly mentioned the age of the B-M reversal boundary. Instead, the Pacemaker paper referred back to the 1973 Shackleton and Opdyke paper, which clearly stated, more than once, that an age of 700 ka years had been assigned to the B-M reversal.[15]

In fact, the second writer seems confused on another point, too. The Pacemaker authors used planktonic (rather than benthic) $\delta^{18}O$ values in their analysis.[5] Likewise, the V28-238 $\delta^{18}O$ values used to help construct the timescales for the two Indian Ocean cores were primarily planktonic, although some benthic values were also used.[15]

Details of the theory still in flux

A third reason to suspect that evidence for the astronomical theory is very weak is that uniformitarian paleoclimatologists have apparently not yet 'nailed down' the details of the theory. That the original Pacemaker paper showed dominant spectral peaks at frequencies corresponding to the obliquity and precessional 41 ka and 23 ka cycles can be explained if one assumes that the climate is responding in a *linear* fashion to those particular orbital inputs.[5,20] In such a case, the periods/frequencies of the climate response are the same as those of Earth's orbital cycles.[21] However, one does not *have* to make this assumption. One can also assume that the climate output is characterized by *different* periods/frequencies than the orbital inputs. Many uniformitarian authors have claimed spectral peaks in paleoclimatological data sets that do *not* match the frequencies of the presumed orbital inputs.[22] In fact, a number of uniformitarian paleoclimatologists are experimenting with non-linear models in which this would be the case.[23,24]

Of course, Milankovitch proponents who advocate for non-linear climate responses to the obliquity and precessional orbital inputs could argue that invalidation of the original Pacemaker results is not 'a big deal'. After all, they don't expect the frequencies of the climate responses to the obliquity and precessional cycles to equal the frequencies of those particular orbital cycles, anyway. But if that is the case, then the original Pacemaker results (in which the frequencies of the climate responses *did* agree with those of the obliquity and precessional cycles) should never have been used as an argument for Milankovitch climate forcing in the first place!

Furthermore, Richard Muller and the late G.J. MacDonald have made forceful criticisms of the claim that the prominent ~100 ka spectral peak found in many paleoclimatological data sets is due to changes eccentricity. They claim that it is actually caused by changes in orbital inclination (the angle between the plane of the ecliptic and the plane perpendicular to the angular momentum vector of the planets). However, they acknowledge the speculative nature of their proposed mechanism.[25,26]

One specialist, in the context of defending the theory, nevertheless acknowledged that, "Surprisingly, the [Milankovitch] hypothesis remains not clearly defined despite an extensive body of research on the link between global ice volume and insolation changes arising from variations in the Earth's orbit."[27] But this raises a question, *How does one test a poorly-defined theory?* No doubt, one can reconcile the data within at least some of the hundreds of seafloor sediment cores with at least some version or versions of the Milankovitch theory. But is there a *single* version of the theory that can fit *all* the data? That uniformitarian paleoclimatologists still cannot agree on the details of their model, even after forty years of work, strongly suggests that the answer to that question is *no*.

The 'strongest argument yet' for the theory?

A fourth reason to suspect that evidence for the astronomical theory is extremely weak is a statement made by respected oceanographer and geologist Wolfgang Berger:

> "In the end, the correct timescale [for the marine sediment cores] was a matter of co-ordinating isotope stratigraphy with the results from palaeomagnetism, applying the date found in basalt layers for the Matuyama-Brunhes boundary to cores with known magnetic stratigraphy (as in Shackleton & Opdyke 1973). *The agreement of dating by that method and by Milankovitch tuning (urged by Shackleton et al. 1990) is the strongest argument yet for the correctness of Milankovitch theory* [emphasis added]"[28]

When one considers the revision to the age of the Brunhes-Matuyama reversal boundary, Berger's statement is simply jaw-dropping. Recall that the Pacemaker paper used Shackleton and Opdyke's age estimates for prominent features in the $\delta^{18}O$ record to set up the timescales used in the analysis. But these age estimates were obtained using an assumed age of 700 ka for the B-M reversal boundary.[29] However, the 1990 paper by Shackleton et al. is one of the papers that argued that the age of the B-M reversal needed to be raised to 780 ka![30] Berger may very well be correct when he says that the agreement of dates obtained by the methods in those two papers is quite good. But there is an outrageous logical contradiction hiding beneath this apparent agreement. The paper by Shackleton and Opdyke assumed an age of just 700 ka for the B–M reversal boundary, while the 1990 paper by Shackleton *et al.* required that the age for this same reversal be 780 ka. Moreover, uncertainties for such age estimates of the B–M reversal tend to be ~10 ka, implying that the two different age estimates are truly discordant.[9,31] If Berger is right, and this is indeed the strongest argument yet for Milankovitch climate forcing, then it is probably safe to say that the theory is in serious trouble!

Fifty years of failure

Despite the many theoretical problems with the Milankovitch theory, it has been widely accepted because of the results of time series and/or spectral analysis.[32,33] The results of these analyses are the only real argument in favour of the theory. Yet, additional analyses of paleoclimate data invariably result in contradictions to the theory.

For instance, a decade before publication of the Pacemaker paper, Cesare Emiliani published another paper in *Science* that seemed to show extremely convincing evidence for the Milankovitch theory, also obtained from seafloor sediment data.[34] Emiliani concluded that $\delta^{18}O$ 'wiggles' in the sediment cores were primarily temperature indicators, with as much as 70% of the variation in the $\delta^{18}O$ 'wiggles' resulting from temperature variations. Yet this interpretation of the $\delta^{18}O$ data is now generally out of favour. Most uniformitarian paleoclimatologists now believe that the $\delta^{18}O$ variations are mainly indicators of changes in global ice volume, rather than temperature *per se*.[1,35]

Emiliani's 'confirmation' of the Milankovitch theory seemed to show near-perfect correlation (a correlation coefficient of 0.997!) between the depths of supposed temperature minima (indicated by maximum $\delta^{18}O$ values) and the calculated times at which 65° N summer insolation were a minimum. However, Emiliani's confirmation of Milankovitch climate forcing was heavily dependent on data from a single sediment core.[36]

Moreover, uniformitarian scientists later revised Emiliani's timescale, increasing it by about 25%, to reflect ^{231}Pa and ^{230}Th measurements made on Caribbean core V12-122.[36] Hence, this apparent confirmation of the Milankovitch theory was soon abandoned and forgotten, despite Emiliani's apparently impressive correlation. Could this perhaps be a lesson to Christians who are tempted to embrace the latest claims of evolutionary scientists, due to results that seem outwardly impressive, despite the fact that those claims contradict Scripture?

Ironically, this timescale revision resulted in a new age assignment of 127 ± 6 ka for the MIS 6-5 (or Termination II) boundary, an age estimate that was then used in the Pacemaker paper.[5,36] As noted earlier, the 1976 Pacemaker paper was seen as providing strong evidence for the Milankovitch theory. Yet we have already observed that this apparent confirmation of the theory relied on an age estimate of 700 ka for the Brunhes–Matuyama magnetic reversal boundary, an age no longer accepted by uniformitarian scientists. In fact, the age of the B–M reversal boundary has slowly 'crept upwards' over the years. Sometime prior to 1979, it was revised to 710 ka.[37] By 1979, this age had been revised still again to 730 ka, due to a revision in the K-Ar decay constants.[31,37] Yet, in the 1990s, uniformitarian scientist arbitrarily revised the age of this reversal boundary to 780 ka, overruling the K-Ar age for this boundary, in an attempt to reconcile wiggles in other sediment cores with the theory.[7,8] It was only after uniformitarians 'needed' this higher age that it was ostensibly 'confirmed' by radioisotope dating.[9]

Of course, this revised age for the B-M reversal boundary undermines the original Pacemaker paper results. So it seems that history has repeated itself. Just as Emiliani's apparent confirmation of Milankovitch climate forcing was overturned by a subsequent age revision, the apparent 'Pacemaker' confirmation of Hays, Imbrie, and Shackleton have been overturned in a similar manner—although secular paleoclimatologists seem unwilling to acknowledge this!

This overview reveals a pattern: uniformitarian scientists obtain what they believe is a confirmation of the Milankovitch theory, but contradictions with the theory eventually emerge as new data are examined.

Implications for geochronology

Despite the fact that the details of the Milankovitch (or astronomical) theory are still in flux, it plays an enormously important role in geochronology. Now that most uniformitarian scientists believe (mistakenly, I would argue) that the theory is firmly established, they use it to assign ages to other seafloor sediments via a technique called 'orbital tuning'.[38] The tuning method has been described this way: "The general approach is to stretch, squeeze, and shift portions of a climate record so as to maximize its correspondence with a curve derived from the time history of changes in Earth's orbital configuration, a process referred to as orbital tuning."[39] However, this tuning process requires the tuner to make *assumptions* about *how* the climate responds to the orbital signal.[40,41] But, as we have already seen, paleoclimatologists do not agree on the details of the climate response. Nevertheless, the ages assigned to the seafloor sediments are then used to 'tune' theoretical age models for the deep ice cores of Greenland and Antarctica.[42] For instance, figure 3 graphically illustrates the manner in which dates for the MD97-2120 New Zealand deep-sea core were 'tied' to age assignments for other sediment and ice cores, which, in turn, were *themselves* tied back to the astronomical theory.[43,44]

In fact, the astronomical theory is even used to calibrate the dating standards for the argon-argon radioisotope dating method![45–49]

Of course, if the astronomical theory is unsubstantiated, then these age assignments are in doubt, even by uniformitarian reckoning (figure 4).

Implications for the 'climate change' issue

Creation scientists have long argued that the Milankovitch theory may be contributing to 'climate change' alarmism. Vardiman noted that the astronomical theory is leading many uniformitarian scientists to conclude that our climate is extremely sensitive to minor perturbations:

> "A major result of this need for feedback mechanisms has been the development of a perspective that the earth's climate system is extremely sensitive to minor disturbances. A relatively minor perturbation could initiate a non-linear response which might lead to another 'Ice Age' or 'Greenhouse.' Because of the fear that a small perturbation might lead to serious consequences, radical environmental policies on the release of smoke, chemicals, and other pollutants and the cutting of trees have been imposed by international agencies and some countries. If the basis for the Astronomical Theory is wrong, many of the more radical environmental efforts may be unjustified."[50]

Vardiman's conclusion is substantiated by numerous papers within the uniformitarian literature, which conclude, based on uniformitarian and Milankovitch considerations, that the climate is unstable.[51–57] Hence, the concern that factors like higher atmospheric CO_2 can contribute to some kind of climate catastrophe.

Likewise, the astronomical theory is contributing to fears over possible rapid sea-level rise due to deglaciation. As noted by Wolfgang Berger:

> "The ice-age record has relevant information on this point. As is seen in figure 5, middle panel, the rates of change of the oxygen isotope record *obtained from tuning to Milankovitch forcing* implies considerable amplitudes for the rates of melting (and hence rise of sea level) for the terminations. For the last deglaciation (where dates and thus rates are bolstered by numerous radiocarbon determinations) a change of around 100 m in sea level was achieved within about 10,000 years, for an overall rate of 1 meter per century (Emiliani, 1992). The value may be taken as a realistic baseline for fast melting. The question then is by what factor this rate is temporarily exceeded during major meltwater pulses. [emphasis added]."[58]

Note that past rates of melting and sea level rise are inferred from orbital tuning of the seafloor sediment data. Berger then notes

> "There remains yet another major unknown factor, this one in regard to the trigger or the threshold for the onset of major melting of polar ice masses. Just when can we expect to see a rapid rise of sea level, ten times higher than the present values of a few millimeters per year? We do not know. All we can say, *from experience*

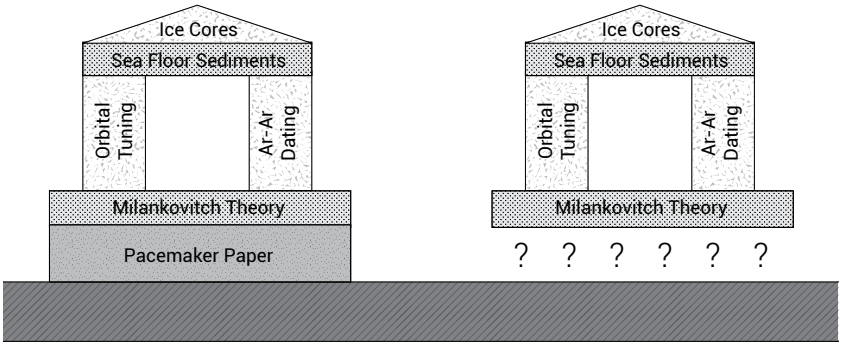

Figure 4. The "Pacemaker of the Ice Ages" paper has become the foundation (a) for modern acceptance of the idea of Milankovitch climate forcing, but now that the results from this famous paper have been invalidated, is there any firm basis (b) for belief in the theory, or for the age estimates obtained from the theory?

> *with the many millennia of the ice-age records in the deep sea*, is that once melting starts, it stimulates further melting for centuries. Deglaciation keeps going once begun in earnest: a great example of the dilemma of the sorcerer's apprentice [emphasis added].[59]

Note that what Berger calls 'experience' is really just a Milankovitch/uniformitarian interpretation of the seafloor sediment data. Thus, these conclusions are derived, not from direct observation, or even from meteorological considerations *per se*, but from a uniformitarian/Milankovitch interpretation of the seafloor sediment data. We have already seen, however, that such an interpretation of the data is logically 'shaky' and *there may be no hard evidence for it whatsoever.*

Conclusions

The secular paleoclimatological community would be wise not to ignore or attempt to 'cover up' the problems in the Pacemaker paper. But given the importance of the paper to secular thinking, they probably will. In fact, both *Science* and *Nature* ran articles commemorating the 40th anniversary of the paper's publication.[60,61] In recent years, secular paleoclimatology has taken several rather serious 'hits' to its credibility. These include the controversy over Michael Mann's 'hockey stick' graph, which purported to show unprecedented warming at the end of the 20th century.[62,63] McIntyre and McKitrick have made devastating criticisms of Mann's papers.[64] Likewise, the East Anglia 'climategate' scandals revealed evidence that influential climate scientists were attempting to 'rig' the climate change debate in rather under-handed ways.[65,66] The last thing secular paleoclimatology needs is another 'hit' to its credibility. And the problems with the Pacemaker paper *could* constitute such a 'hit', if it ever becomes common knowledge that paleoclimatologists were either unaware of the problems in the Pacemaker paper or, worse yet, that they *were* aware of them but ignored them.

It is my hope that this series of papers, particularly the conceptual exercise in part 1, will enable non-specialists to see for themselves that the Pacemaker results should be questioned, even for those who accept 'deep time'.

The evidence for the Milankovitch theory is apparently much weaker than generally assumed. Given the prominent role that Milankovitch theory plays (via orbital tuning) in uniformitarian geochronology, it is possible that many, perhaps *hundreds*, of age assignments could be in doubt, even by uniformitarian reckoning. Likewise, given the prominent role that the theory plays in paleoclimatology, anyone hoping to correctly evaluate and respond to arguments for and against catastrophic anthropogenic global warming (CAGW) should take these weaknesses into account.

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