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# Cyclostratigraphy and Astrochronology

# Part IV: Is the Pre-Pleistocene Sedimentary Record Defined by Orbitally-Forced Cycles?

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## Abstract

**Cyclostratigraphy is a popular method that promises much more precise dates than biostratigraphy or radioisotope dating. Originally, it was pioneered to date Pleistocene glacial/interglacial intervals, but its reach has been steadily extended back through the Cenozoic and into earlier eras using sedimentary cycles. Unfortunately, enthusiasm for its potential has blinded geologists to its problems. Six problems are addressed, revealing the influence of subjective factors not commonly noticed.**

## Introduction

One of the most popular new ideas in stratigraphy is that sedimentary rocks are imprinted by a series of discernible climatic (Milankovitch) cycles caused by slight but regular variations in orbital mechanics (Figure 1). Cyclostratigraphy is the method derived from this view and claims to provide accurate dating on the much more precise order—$10^4$ to $10^5$ years—a much finer scale than radiometric and biostratigraphic dating methods.

Reed and Oard (2015) described basics of the method and the Milankovitch cycles that determine the slight variations in solar radiation that supposedly force climate over timescales as short as 20,000 years. Reed and Oard (2016) summarized the history of the mechanism, and Oard and Reed (2020) showed problems with the Milankovitch mechanism for proposed Pleistocene glacial/interglacial cycles (Figure 2). In this paper, we will explore how well it works in the deeper sedimentary record for pre-Pleistocene sediments.

In 2004, Miall and Miall offered an in-depth evaluation of cyclostratigraphy. Although much has been done since then, their assessment included fundamental issues that cannot be masked by the proliferation of the application. Four of their criticisms are of interest:

1. There are not reliable tests of assumptions.
2. Natural variability in the record exceeds potential climate signatures.
3. There is a tendency among geologists to see cycles in virtually any data string.
4. Potential variations in orbital mechanics over deep time exist.

We examine these concerns, though not in their order.

## Testing Assumptions of Orbitally-Forced Sedimentary Cycles

Miall and Miall (2004) claim that the assumptions of cyclostratigraphy cannot

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**Figure 1. Miocene cyclic deposits, considered of Milankovitch origin, from the Tabernas basin of southern Spain (Verisimilus, Wikipedia commons CC-BY-3.0). Prominent beds are approximately 0.5 m thick.**

be reliably tested (they cannot be tested in any scientific sense, since they are historical hypotheses). They noted that cyclostratigraphy depends on "a hierarchy of five theoretical assumptions":

1. A continuous section or one in which discontinuities are noted and explained.
2. A constant sedimentation rate.
3. A certainty that orbital frequencies can be accurately projected into the geological past.
4. Confidence that sedimentary thickness can be converted to time.
5. Variability caused by facies and hiatuses can be managed by pattern-matching techniques.

In addition to these, several other assumptions hold; some made clearer by the biblical worldview. Cyclostratigraphy requires that the rock record can be converted to time in a globally synchronous manner (Reed, 2008a, 2008b, 2008c, 2008d). This requires very accurate dates for the sediments and assumes these dates reflect history. This is another point at which uniformitarianism and Flood geology diverge into drastically different conclusions. In a one-year flood, trying to use cycles in sediments as dating tools seems much less useful than trying to estimate current velocity or water depth.

Another uniformitarian assumption, that solar radiation changes associated

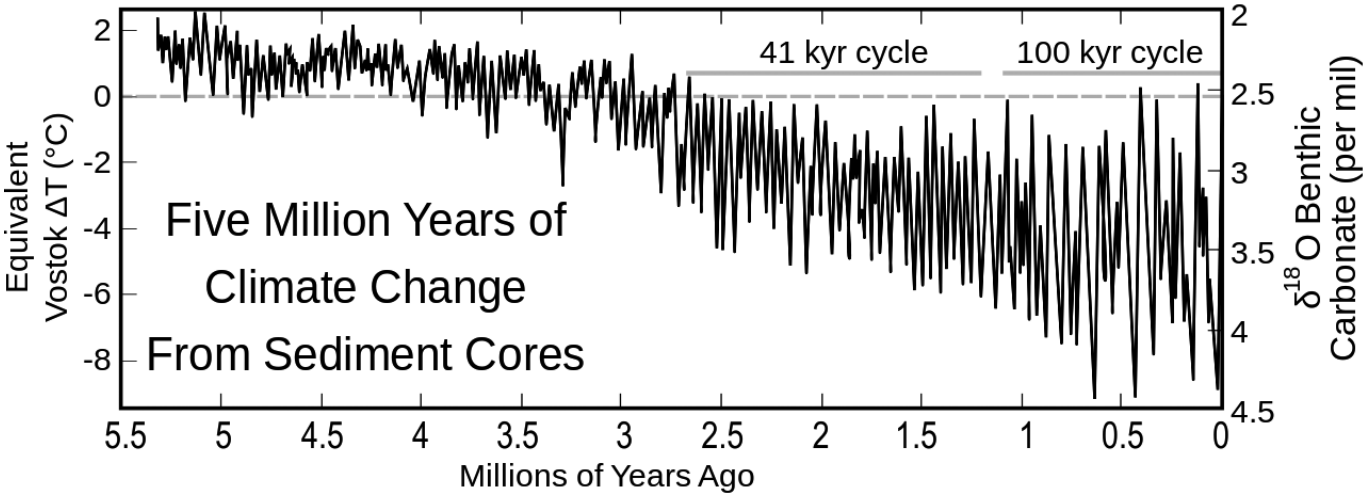


**Figure 2. Reconstruction of the past 5 million years of climate history, based on oxygen isotope ratio of benthonic foraminifera (serving as a proxy for the total global mass of glacial ice sheets) and supposed changes in temperature at Vostok, Antarctica (Robert A. Rohde, Wikipedia commons CC-BY-SA-3.0). The oscillations since 2.6 Ma are believed due to the 41 kyr tilt cycle and the 100 kyr eccentricity cycle. The pre-Pleistocene cycles older than 2.6 Ma are now also assumed caused by the Milankovitch mechanism.**

with Milankovitch cycles are a dominant feature of sedimentary rocks, cannot possibly be true within a diluvial framework. The supposition that climate is the dominant driver only works, in theory, in the idealized uniformitarian world of low-energy, gradualist processes. Even today, we see that "rare events," (Dott, 1983) like storms and tsunamis, leave the largest mark on sedimentation and geomorphology.

Then there is the human factor. Confidence in human reason (i.e., the ability to objectively assess evidence and certainty in both scientific and historical studies) is crucial to understanding the past in either framework. But only one worldview justifies those assumptions—the biblical worldview (Reed and Klevberg, 2015). Cyclostratigraphy assumes that subjective factors, such as the bandwagon effect, are minimized. Miall and Miall (2004) noted the problems with subjectivity, tracing the bandwagon effect in uniformitarian's increasing confidence in cyclostratigraphic analyses and conclusions over recent decades.

## Problems in Cyclostratigraphy

These assumptions and criticisms by secular authors shed light on numerous problems with cyclostratigraphic dating of the pre-Pleistocene rock record (Oard, 1997a). Table 1 lists six of these problems. Most of these were previously pointed out by Miall and Miall (2004) above.

## Problem 1. A Discernable, Accurate Astronomical Record through Deep Time

Uniformitarian scientists assume that the obliquity, precessional, and eccentricity Milankovitch cycles deduced for the past million years or so can be extrapolated far back in time (even older than the 66 Ma of the Cenozoic). However, Lasker et al. (2004, 2011a, 2011b) have shown that the gravitational cause of the Milankovitch cycles is chaotic, and so the cycles could have changed frequencies in the past. Since the two eccentricity cycles are commonly used to date pre-Pleistocene sediments, Lasker et al. (2011b, p. 1) stated, "As a result [of the unpredictable behavior of the asteroids Ceres and Vesta after 400,000 years], it will never be possible to recover the precise evolution of the Earth's eccentricity beyond 60 Myr." That is why, at present, geologists are cautious in extending cyclostratigraphy beyond the Cenozoic, but we predict that future studies will return the desired answers and push the dating method as far back as is needed.

**Table 1. The main problems with pre-Pleistocene cyclostratigraphy.**

| |
|---|
| 1. Knowing an accurate astronomical record through deep time |
| 2. Knowing how Milankovitch cycles produce a climate response |
| 3. Knowing accurate dates for sedimentary rocks to date cycles |
| 4. Knowing past sedimentation rates |
| 5. Accounting for natural variability |
| 6. Eliminating subjectivity and bias, especially the bandwagon effect |

The same can probably be said for the tilt and precession cycles, since these too depend upon changing solar system orbital geometry that is chaotic. The floating Milankovitch chronologies beyond the Cenozoic are disconnected from absolute time but are anchored to "independent" geochronometers (e.g., radioisotope-dated horizons, magnetic reversals, or biozone boundaries). Secular scientists have an approximate time for these cycles, but they still must assume that they were caused by the Milankovitch mechanism.

The highly mathematical models of Lasker et al. (2004, 2011a, 2011b) need precise orbital geometry extrapolated into the past. We wonder whether such extrapolations, even into the early Cenozoic, are that accurate if two asteroids in the asteroid belt can perturb the Earth's eccentricity cycle. Hinnov and Hilgen (2012) provide a status report of cyclostratigraphy and astrochronology in relation to the Geologic Time Scale. Needless to say, none of this applies to sedimentation in the Flood model, which was rapid.

## Problem 2. A Perpetual Milankovitch Climate Signal?

Milankovitch cycles produce only slight seasonal and hemispheric changes in solar radiation, insufficient for glacial/interglacial oscillations (Oard and Reed, 2020). Yet scientists persist in attributing both Pleistocene and pre-Pleistocene cycles to this weak mechanism. But if the Milankovitch signal is tied to a glaciation, how would it manifest in strata lacking glacial signatures, such as pre-Pleistocene sediments? Pre-Pleistocene glacial-related strata are currently restricted to the late Paleozoic, the late Ordovician, and the mid to late Precambrian (Oard, 1997b). If the Milankovitch cycles extend back through deep time, and operate in a predictable, uniform manner, it is fair to ask, "Where are the innumerable ice ages?"

If few are evident, it must follow that the Milankovitch variations cannot bear the weight of cyclostratigraphy. Only if these faint signals can trigger other climate signals detectable in sedimentary rocks in all climates, times, and depositional environments can the method be reliable. Though cautious early on, many geologists (i.e., Brack et al., 1996) today believe that such a signature is present and available for high-resolution dating in rocks extending back through the Phanerozoic (Hilgen et al., 2015; Hinnov and Hilgen, 2012).

Reed and Oard (2016) noted that cycles are detected in oxygen and carbon isotopes, clay types and abundances, lithofacies, microfossil assemblages, and even color. For example, cycles in Triassic carbonates in Austria are thought to represent eustatic (sea level) changes caused by Milankovitch cycles (Cozzi et al., 2005). Although the authors are not clear how the climate change affected sea level, they presume that oscillations between "deep" and "shallow" water were recorded in features within the limestone. Many more assumptions go into these interpretations. Researchers are short on mechanisms connecting the solar insolation changes with sedimentation cycles:

> Processes of sedimentation clearly depend on many more variables than insolation alone, and variations in insolation must be propagated through the complexities of the system before they can be encoded in the sediment. The mechanisms for this are not yet clear and they may be many and various. (de Boer and Smith, 1994, p. 6)

## Problem 3. Knowing Accurate Dates in Sedimentary Rocks to Date Cycles

The sedimentary sequence must have accurate dates in order to discern any cycles, but other dating methods are generally about two orders of magnitude less precise (except for paleomagnetism, which requires calibration to radiometric dates). Smith et al. (2015, p. 7) stated:

> As Hilgen et al. (2014) point out, only the availability of sufficiently precise numerical dating of sediments could ever finally provide independent support for an orbital link with cyclic sedimentation.

Secular scientists must assume all their various dating methods are accurate. Therefore, the Milankovitch cycles are not really an independent dating method but depend upon these other dating methods, an example of confirmation bias. Milankovitch cycles purport to provide a much finer subdivision of dates between the "tie points" provided by the other dating methods. The advantage is more precise dating. But as seen in Figure 3, the challenge of interpolating between tie point dates is severe. For instance, if biostratigraphy

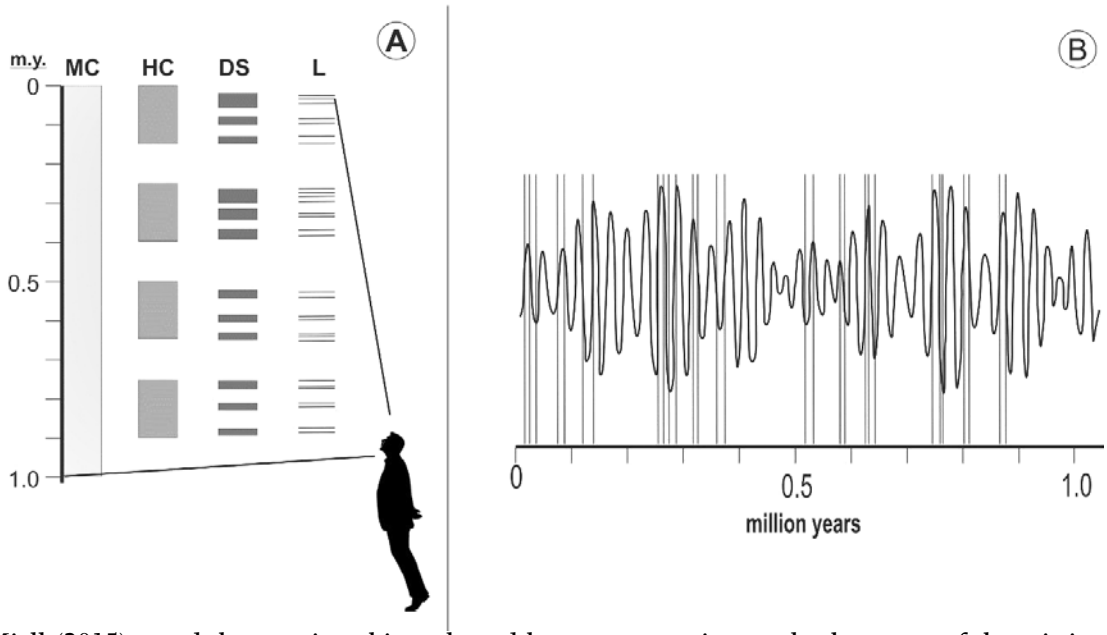


**Figure 3. Miall (2015) noted that stratigraphic scale and human perception masks the extent of the missing record. (A) When the rock record is presented at a gross scale, such as a million-year range (MC), with only large regional unconformities shown, it overstates the record. Finer depictions, such as a hundred thousand-year cycle (HC), a depositional system scale (DS), or a lithesome scale (L) shows the continual removal of the geologic record. (B) This clearly demonstrates the inability to adequately calibrate actual sediment (the lines) relative to missing section (white space between the lines) to Milankovitch cycles.**

provided a date of 50 Ma for the bottom of a sequence, and a radiometric date 10 meters up the same sequence provided a date of 45 Ma, then we would expect 5 million years-worth of cycles. But do small unconformities distort the correlation of cycles? How do we know which cycle to choose: the 21,000-year precession signal, the 41,000-year tilt signal, the 100,000-year eccentricity signal, or the 400,000-year eccentricity cycle? Miall and Miall (2004, p. 39, emphasis added) noted:

> We suggest that attempts to develop a time scale with an accuracy and precision in the $10^4$-year range by calibrating it against conventional chronostratigraphic dates up to two orders of magnitude less precise presents a *fundamentally flawed methodology*.

When speaking of chronostratigraphy and geochronology, Gradstein (2004) also claimed that geochronologic (absolute) ages were matters of "discovery" and "estimation." This is the opposite of common sense. We would expect that the chronostratigraphic position of strata would be "discovered" through field work, and that dates would simply be measurements (c.f., Ferrusquía-Villafranca et al., 2009). It sounds like the retreat from chronostratigraphy towards geochronology is the natural progression of the overall trend away from empirical stratigraphy (Reed et al., 2006).

Hilgen (1991; cp. Hilgen et al., 2015) and Shackleton et al. (1990) independently derived orbital cycle chronologies based on matching sedimentary cycles and oxygen isotope curves to the extrapolated history of Milankovitch insolation changes. Their results were at odds with widely accepted potassium-argon dates, but not rejected. Instead, "improved" radiometric dates were introduced to confirm the validity of the astronomical time scale approach (Weeden, 2003, p. 3). In other words, the conflict between "data" was resolved in favor of the preferred "new" approach and then "validated" by revised dates once the answer was "known." Though presented as scientific progress, it might also be seen as an example of manipulating measurements to get a desired result (Hebert, 2019). This is why the bandwagon effect is a real concern for cyclostratigraphy.

Another example of this type of manipulation was seen in one of the classical studies involving the Neogene Monte dei Corvi succession in Italy: "The discrepancy leads to an adjustment of the dating of the two ash layers—the independent data upon which the calibration is based…." (Bailey, 2009, p. 347). A comment was added: "The 'astronomical' time calibration thus supersedes the radiometric data on the basis of two key assumptions, namely that the calibrated section was continuously accumulated and that the matching of the smoothed carbonate content data with the theoretical orbital cycles is unambiguous…."

In addition to radiometric and biostratigraphic dating, geologists use the standard polarity magnetic timescale to calibrate cycles, but this dating method simply adds uncertainty. Murphy and Salvador (1999, p. 271) noted that magnetic reversals "have relatively little individuality, one reversal looks like another…." Comparisons and correlations between Milankovitch cycles and paleomagnetic reversals thus become subjective; both suffer from the same basic problem—determining a unique point from strings of repeating data. Torrens (2002, p. 257) referred to what he called the "bar-code effect" of dealing with "basically repetitious, often binary" data of orbital cycles and magnetic reversals:

> The problem is that, if one barline is missed or remained unread, the bar-code becomes that, not of the next object, but that of a quite different object. The proximity of the next object, becomes no proximity at all.

## Problem 4. Need to Know Past Sedimentation Rates

Correlation of imprinted Milankovitch patterns assumes that the sedimentation rate is known and constant. Both assumptions are commonly made (Miall and Miall, 2004), but are incorrect (Bailey and Smith, 2008). Any undetected hiatus or change in sedimentation rate affects the cyclostratigraphic result. Modern depositional environments demonstrate that slow and steady sedimentation is unrealistic.

### A) Ubiquitous Gaps Preclude Accurate Rate Estimates

Major unconformities erase millions to hundreds of millions of years of supposed time from the rock record (Reed and Oard, 2018). These have been identified in the field and geologists assemble the puzzle of remaining parts stratigraphically. But the advent of neocatastrophism in the late 20th century highlighted an aspect of the record hidden for long decades by Lyellian gradualism—episodic sedimentation dramatically reduces the "history" actually contained in the rocks. Ager (1973) noted that the record was composed mostly of gaps. This created a cognitive dissonance in geologists; they could not disagree with Ager's conclusion, but had to act as if it was not true.

To further complicate matters, Bailey and Smith (2008, 2010) developed a method for quantitatively assessing the presence of hiatuses of all scales using gamma ray logs. Gamma ray logging is a method of measuring naturally occurring gamma radiation to determine the type of rock or sediment in a borehole or drill hole. Different types of rock emit different amounts and different spectra of natural gamma radiation. Their Layer Thickness Inventory has been applied to thousands of logs and has shown that discontinuities are the rule rather than the exception. Reed (2016) concluded that their work was a powerful argument against traditional stratigraphy. Miall

(2015) admitted that breaks occur at all scales and are common (Figure 3), but has attempted to save uniformitarian history by linking physical scale to temporal scale. Thus, large regional strata adequately represent deep time because they are composed of a representative sample of small, more rapidly deposited components (Reed, 2018).

Miall (2014) demonstrated the extent of missing time in the Mesaverde Group, Book Cliffs, Utah, USA. He showed that the sedimentary rocks seen in the field represent only a *fraction* of the total time ascribed to the Mesaverde Group. Even worse, he showed that there is very little field evidence for this missing time. Then he noted that the same kind of obscure gaps are *typical of strata worldwide* and that sedimentation provides a record of only 10% of the time, while 90% is not represented by any strata at all. It is worth noting at this point that Miall is committed to uniformitarianism and its derivative history (Miall, 2015).

Missing strata with little evidence that it is missing is a fatal problem, *given the constraints of their worldview*. Christians have often erred in allowing the presuppositions of Christianity to be appropriated by believers in naturalism: nature is all there is. Uniformity must hold true, and be as close to static as possible, if our present scientific reality is to be extrapolated by billions of years into the past (Reed, 2001). If 90% (using Miall's estimate) of the tangible historical record is absent, then what level of confidence do the remaining scraps yield? What if it is really 99%? Secularists have been claiming for more than 200 years to be objective rational empiricists while saying Christians cling to faith contrary to reason. But who is walking by faith and who by sight? Although some geologists would disagree, Miall (2015, p. 13) points out that Bailey and Smith's (2010) work answers that question: "The notion of continuous deposition, on which the historicity of the record depends, has no theoretical or evidential basis." At the edge of the precipice, however, Miall (2015, p.13) acknowledges the implications: "Is the stratigraphic record fundamentally unrepresentative of the geological past? These conclusions would appear to invalidate virtually the whole of the last two centuries of stratigraphic progress."

Though Miall goes on to affirm uniformitarian history, he somehow does so conforming to the conclusion of Kravitz (2013) that pragmatically attractive, natural history exists largely in the minds of geologists.

### B) And Neocatastrophism Makes It Worse

The fad of neocatastrophism rids geologists of the albatross of Lyell's gradualism (Reed and Oard, 2017), but with a belatedly unintended consequence of pointing to greater uncertainty in the rock and fossil records. It is bad enough if the rock record is composed mostly of gaps; it is infinitely worse if the bits and pieces that remain were deposited rapidly. Two geologists recently noted:

> One [problem] is a misconception of the amount of geologic time represented by the rock record. Conodont assemblages embodied in the "Standard Zonation" may be recognized within lag deposits, which produce phantom zones that expand the apparent time represented by a rock interval and represent clastic provenance and hydraulic sorting rather than time. (Macke and Nichols, 2007, p. 265, brackets ours)

In other words, even when rocks are present, the standard uniformitarian explanation does not account for the time. For example, Reed (2000) showed that the ~20 million years represented by the volcanic flows of the Midcontinent Rift System vastly overstated the actual time of emplacement that was in days to weeks. The public thinks the rock record is a jigsaw puzzle, with a few pieces missing. In reality, *most* of the pieces are gone. The vast majority of rocks claimed to have been deposited across deep time do not exist. You wouldn't suspect the problem from most published material. Uniformitarian geologists are quick to admit that there are no cases anywhere of continuous deposition over just one stratigraphic stage, usually a few million years, much less the 4.6 billion years of deep time, but they continue to believe that it does not affect their historical narrative (Miall, 2016).

Discontinuities in the rocks do not present similar problems for Christians for two reasons: (1) the rocks are a much more complete record of the Flood, with many "gaps" representing hydraulic changes, not time, and (2) Christians are not positivists (assuming nature is all that exists); there is an external framework of history in the Bible that guides forensic uncertainty.

## Problem 5. What about Natural Variability?

The commitment to uniformitarianism creates a blind spot. Even geologists who are neocatastrophists tend to default to the gradualist paradigm until evidence proves otherwise. As with varves or ice layers, they simplistically assume that the target sediments were deposited slowly, uniformly, and in response to regular climatic variables. They assume static conditions for thousands to millions or billions of years, even when observations of modern depositional conditions show otherwise. Remove those assumptions and the whole theory crumbles, for both ice layers and varves (Oard, 2005, 2009).

Catastrophic sedimentation renders cyclostratigraphy invalid. Sedimentary rock is the product of: (1) a source of sediment particles, (2) a mode of transport, (3) deposition influenced by local tectonics, and (4) its likelihood of being preserved. For cyclostratigraphy to work, all four must be ideally *uniform*. That's hard to imagine. For example, diagenesis

alters carbonate sequences (Neuendorf et al., 2005) and can distort any climate signal (Westphal et al., 2004). A large submarine slump would generate turbidites that could hypothetically show a regular cycle of interbedded lithologies. Yet deposition was instantaneous. Could a plot of the various chemical ratios in such a deposit be calibrated to astronomical cycles? Smith et al. (2015, p. 6) state:

> The question is whether orbital forcing leaves an imprint on the record that can be distinguished from that of the many non-cyclical processes in play along the routing system. Much current research is focused on the time-lags and hence buffering that the routing system interposes between the site of sediment production and the sink areas of long-term preservation, suggesting that these effects can be more than enough to damp any cyclic forcing of sediment supply.… The contrary idea [to the recording of Milankovitch cycles] are: (1) that the translation of variable insolation [caused by Milankovitch cycles] into environmental change, and thence into sedimentary processes, is non-linear; and (2) that due to their non-linear operations and the hiatus-riddled character of their outputs, sedimentary systems provide poor recording media for quasi-periodic insolation variations.

It should go without saying that if the Flood really happened that the entire method of cyclostratigraphy, as well as radiometric and biostratigraphic dating, is irrelevant to history. For example, the early and late stages of the Flood were probably marked by dramatic volcanism and tectonic activity. The local increases of ions and temperature in seawater would have swamped any solar signal, and combined with particles in the atmosphere, would have been responsible for unpredictable variations in solar radiation far in excess of any orbital variation, even if the variations in the sediments were not caused by hydraulic factors.

## Problem 6. The Human Factor (Influence of Presuppositions)

Of course, the fundamental problem of secular natural history is still there. All the *scientific* measurements in the world are made in the present and the conclusions are only as historically reliable as the *unscientific* assumptions used to interpret the measurements. Subjectivity and uncertainty are inherently part of such studies. Miall and Miall (2004) provide an extended discussion of this problem, noting that the method has become a "black box" and has not been subjected to the scientific scrutiny needed to validate its assumptions and methods. In doing so, they provide a good summary of the early history of the method and cite key early references. Furthermore, there is a tendency for geologists to "see" cycles that do not exist:

> Pollitt et al. (2014) investigate a different aspect of layering in stratigraphy, in this case the geoscientist's tendency to observe cyclic patterns in layering relationships where none necessarily exists, a tendency classically investigated by Zeller (1964). (Smith et al., 2015, p. 5)

Though accomplished decades before the rise of cyclostratigraphy, Zeller's (1964) study of correlation seems applicable. Different geologists, given a variety of logged sections to correlate, came up with divergent interpretations. These were not real cycles. When they complained that the author had "fooled" them, Zeller (1964) noted that nature does the same. Her warning against inherent uncertainties in natural patterns, subjective confirmation bias, and overconfidence in interpretation should be heeded by practitioners of cyclostratigraphy.

These problems pale beside the logical shortcomings of the method, particularly the circular reasoning inherent in its assumptions and results. Speaking of evidence of orbital cycles in sedimentary rocks, one geologist noted:

> Classically, however, this evidence derives from *assuming* model (a) or model (b) [his two models of cyclicity in sedimentary rocks used by proponents of cyclostratigraphy] and showing that these assumptions will lead, by cycle counting or "tuning," to one, or more of the expected outcomes in terms of orbital periodicities. This tendency to circular reasoning is endemic in cyclostratigraphic analysis and is acknowledged by its proponents…. (Bailey, 2009, pp. 347–348, emphasis in original, brackets ours)

Miall and Miall (2004, p. 42) reinforce this deduction:

> In research where the science is complex, with results dependent on data of varying quality from many sources, or in cases where the technology is not fully developed, the power of the preconceived idea may overwhelm "objectivity," and the impact of social influences become more clearly evident. The impact of social influence, however, cannot be separated from the scientific practices it generates and is ultimately influenced by.

## Summary

Cyclostratigraphy is a growing trend in geology and will probably continue to be so for some time. However, numerous fundamental problems will continue to haunt it, and eventually should lead to its downfall. Its basis in astrochronology requires a rigid gradualism contrary to the accounts of the Creation and the Flood, and its application in sediments appears to involve a high degree of wishful thinking and cognitive dissonance. For these reasons, creationists should be very wary of using its conclusions.

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