Letters

COCCOLITHOPHORES AND CHALK LAYERS

Dear Editor,

Your 1994 article in CEN **Technical Journal**[1] on the rapid formation of chalk in the geological record relies primarily upon two studies that propose solutions to the problem of how to compress the production of hundreds of metres of calcareous oozes (or chalk) into a short time-frame. One of the two is a 1986 paper by John Woodmorappe,[2] who depended heavily upon the calculations found in the 1985 study by Ariel A. Roth.[3] Hence, we have only one set of calculations for coccolith oozes to evaluate. Coccolithophores are marine algae that surround themselves with 12 to 100 tiny platelets or coccoliths. When the parent organism dies, the platelets disintegrate and gradually descend to the ocean's bottom to collect as calcareous (calcium carbonate) ooze.

Turnover Rates and Longevity

Based upon a turnover rate of 2.25 times per day (that is, each coccolithophore divides about every 10.5 hours to form a new coccolithophore), Roth argues quite convincingly that 100 metres of coccolith ooze could be produced in as little as 200 years.[4] A careful check of the mathematics employed by Roth reveals that indeed 100 metres of ooze could be produced in 200 years if the turnover rate is 2.25 divisions per day as assumed. However, such calculations are seriously flawed because they do not take into account the longevity of the coccolithophores. The statistics are correct if and only if the majority of coccolithophores live at most about 12 hours, at which time the parent generation dies. One important element that Roth correctly noted in his coccolith

calculations is the present concentration of such organisms in sea water during algal bloom situations, such as one would find in nutrient-rich water, perhaps at the time of the Flood. According to Roth, research from Oslo Fjord has found a concentration of 13 million per litre in sea water. This figure is consonant with a similar study off the shores of Jamaica indicating a concentration of 10 million coccolithophores per litre, as reported in your excellent survey article in **CEN Technical Journal**.[5] What Roth fails to include in his article (and what is also missing in John Woodmorappe's study and yours as well) is the number of generations inhabiting the same litre of sea water simultaneously. The 13 million cocco-lithophores per litre would be inclusive of organisms at all stages of growth — some days, weeks, or even months old — and not just the generation less than 12 hours old that is the basis of the above-mentioned studies. The key element of longevity has been overlooked. The fact that a given litre of sea water has multiple generations at various stages in their life should be considered in all productivity calculations.

Longevity information can be obtained from the 1978 landmark study by Bilal U. Haq,[6] an expert on coccolithophores. He notes that *'complete life cycle studies on coccolithophores are rare',*[7] which no doubt explains why none of the creationist studies have considered longevity as an important variable. Most coccolithophores have a two-phase life cycle composed of first a motile phase and second a non-motile (or non-flagellar) phase. Often the motile phase is characterized by the absence of coccoliths or by greatly reduced coccoliths. Since coccoliths are the only calcium carbonate portion of the organism, in practical terms this means that in most cases little or no calcium carbonate is produced in the first 12 hours of the organism's

existence. Haq[8] theorizes that the reason most calcium carbonate platelets are produced in the second or non-motile phase is that the motile phase consumes so much energy with flagellar motion that there is little left for platelet formation. One species, *Coccolithus pelagicus,* has a motile phase lasting five to eight weeks followed by a non-motile phase of just two weeks[9] — the latter phase being the stage when the coccolith platelets receive their greatest development. Using this species as a typical example, one can suggest that at least seven weeks or 50 days should be allowed for coccolithophores to reach full maturity. Oceanic algal blooms take weeks to reach full development, which then would be correlated with the longevity of the organisms involved.

The turnover rate for coccolithophores in a state of equilibrium should be set at 50 days minimum, not 12 hours as in all creationist studies relying on Roth's data. (The turnover rate based upon the high productivity of coccolithophores at the start of a bloom reflects a disequilibrium state and should not be used.) Thus, the actual turnover rate should be 100 times longer than what has been proposed (that is, 50 divided by 0.5), which makes all calculations for chalk production rates in error by two orders of magnitude. One hundred metres of coccolith ooze can be formed in a minimum of 20,000 years instead of the 200 years presently proposed. This also means that the 400 metres of Cretaceous chalk from England, dealt with in your article,[10] would have taken a minimum of 80,000 years to form, provided that present-day rates are valid for past periods. However, if Cretaceous waters were warmer, as all isotopic studies seem to indicate, the production time for Cretaceous coccoliths could have been much faster than today's rates.

Productivity

One can illustrate this method for

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coccolith productivity calculations by taking the productivity of a forest as an example. Let's suppose one wishes to calculate how much wood biomass can be produced by one acre of a mature forest. A 'mature forest' can be defined as a forest that has reached a state of equilibrium, whereby the growth of new trees exactly replaces the trees that die, in terms of wood biomass. Let's suppose also that one is unable to weigh the total amount of wood that is produced by dead trees in a year's time, all of which will eventually contribute to litter or compost on the forest floor. Let's also assume that trees grow at a constant rate during their lifetime.

One way to calculate wood productivity rates is to harvest the entire 'standing crop', or entire one-acre forest, and carefully weigh the total amount of wood. Then the total amount is divided by the average longevity of the individual trees. Longevity involves calculating through dendrochronology the age at which trees die by natural means (for example, disease, lightning, wind storms, drought, etc.). For argument's sake, let's suppose that the average longevity is 80 years, which when divided into the total tonnage of wood will yield average annual productivity. If the weight of wood in the standing crop amounts to 80 tons, then productivity is easily calculated as one ton of wood per year per acre. One should keep in mind that this is purely a rough estimate of average annual productivity, and that the more accurate method of calculating productivity for any given year is to measure the weight of all dead wood —fallen or standing — produced in a year's time. But sometimes this more accurate method is not feasible.

One can readily detect the parallel with calculating coccolith productivity in the oceans. If one is unable to add up the number of coccoliths that sink to the ocean bottom per year — perhaps because it is difficult to lower sediment traps into 3,000 metres of water — then one must find an alternate method for

calculating productivity. One could count the number of new coccolithophores added to a litre of sea water per day, but that will give misleading results because the number of coccolithophores is not the same as the number of coccolith platelets, and it is platelets alone that contribute to the deep-sea ooze. A better method for calculating productivity in the marine environment is to divide the 'standing crop' (or total number of coccolithophores per litre of water) by the average longevity of coccolithophores. This will not yield as precise a result as perhaps other methods, but it is the best one can do with the information given. The standing crop of 13 million coccolithophores per litre of sea water then is comparable to 80 tons of trees per acre, and the longevity of 50 days for coccolithophores is parallel to the figure of 80 years for average tree longevity. Dividing the former piece of information by the latter in each case yields a rough estimate of plant productivity. The one assumption is that the growth rates have been fairly constant during the lifetime of the individuals.

One must avoid the pitfall of confusing plant productivity with animal productivity, especially the productivity of microorganisms such as protozoans or bacteria. Bacteria productivity can be calculated on the basis of doubling time, or the time between generations. Doubling time is often very short, thus yielding amazingly fast production rates for bacteria when in a favourable environment. It is different with plants, for they are limited by the amount of sunlight. Calculations based upon doubling time or the time between generations will certainly lead to erroneous results. Let's suppose the one-acre forest is composed entirely of oak trees, and it takes five years for an acorn to grow to maturity such that it can produce another oak tree with acorns. Theoretically the generation span is five years, and if there's unlimited space and nutrients a forest

could double the number of trees every five years. But obviously a forest that has reached equilibrium in 80 years is not going to double its productivity every five years. To use the time between generations which theoretically is five years will yield productivity results that are 16 times too high (or 80 divided by 5). So with coccolithophores: to base calculations of productivity on the time between generations, which has been proven in many cases to be less than 12 hours will yield productivity rates that are grossly over-estimated.

A valid criticism of the above calculations is that a longevity of seven weeks on average for a particular species of coccolithophore is a hypothetical case derived from ideal laboratory settings. One can argue that in a natural setting actual longevity is much less, and that is true. No one has been able to (nor perhaps will be able to) calculate longevity in the marine setting. Even if one were to suggest that actual longevity should be only one-fourth of what has been proposed for our calculations, one still has the problem of fitting all coccolith post-Flood deposits into a short time-frame because more than 90% of all coccolith post-Cretaceous oozes are pre-Pleistocene or pre-glacial. A period of 5,000 years is too long to fit the traditional biblical chronology for the period from the Flood to the onset of glaciation. The additional problem is whether to place the Cretaceous oozes as post-Flood or pre-Flood because in either case they would have occupied a period of 20,000 years for production, if average coccolith longevity is one-fourth the original 7-week period.

One additional method can be suggested for calculating coccolith production rates, and possibly this one is the most accurate for the time being. It is comparable to measuring the productivity of grapefruit in a citrus orchard. Let's assume that one grapefruit is equivalent to one coccolith platelet, and in that case the tree would

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be comparable to the entire coccolithophore organism. This method involves counting the number of coccoliths that can be produced within a certain time period of a parent organism. As mentioned previously, one organism can bear 'fruit' amounting to 12 to 100 platelets at maturity. According to P. Westbroek, one of the world's leading coccolithophore experts today, a parent coccolithophore can produce one coccolith every two hours only during daylight hours because of reliance upon sunlight for photosynthesis.[11] This rate is based upon the species *Emiliania huxleyi,* which composes 30–70% of all coccolithophores in today's mid-latitude oceans.[12] The reproduction time for *Emiliania huxleyi* is extremely rapid in nature, ranging from its slowest rate of 1.2 divisions per day to a high of 4.8 divisions per day in the Black Sea.[13] However, most of the coccolithophores produced during these high turnover rates during bloom conditions are in the non-coccolith state of the organism — either the naked stage or the scaly stage.[14] Let's assume that the bloom conditions of coccolithophores from a Norwegian fjord, upon which Roth makes his calculations, are mostly composed of *E. huxleyi,* which has the three states or stages — coccolith, naked, and scaly. We are proceeding to utilize only the coccolith (or C) state for calculations, which we will assume to be about one-third of the total number of coccolithophores in the bloom, not having precise percentages available. Since coccolith productivity takes place only during daylight hours, we can calculate an average of five coccoliths being produced every 24 hours based upon one coccolith produced every two hours during the approximate ten hours when sunlight is at an optimum during the daytime. Roth's calculations are based on 2.25 divisions every 24 hours with an average of 20 coccoliths for each generation, which would yield a total of 45 coccoliths per 24 hours. This rate is nine times faster than ours (45 divided

by 5). Furthermore, if we assume that the count of coccoliths in the Norwegian fjord results in only one-third of the total being in the coccolith-bearing or non-naked state (based on the existence of three states for *E. huxleyi),* then we must multiply productivity by a factor of three, resulting in a total productivity rate according to Roth's calculations that is **27** (or 3 x 9) times faster than ours. Instead of a 200-year interval for the production of the ocean's post-Cretaceous oozes, a more accurate figure as a minimum would be 5,400 years (or 27 x 200), if we assume maximum productivity without interruption during the entire interval. This accords with the conclusion that a more reasonable longevity figure in nature would be about 12.5 days instead of 50 days, yielding a maximum productivity time of about 5,000 years for the 100 metres of ooze, according to the longevity method. This also accords well with satellite data that are derived from one particular Atlantic Ocean bloom lasting a total of three weeks,[15] which suggests a natural longevity of *E. huxleyi* for a period of perhaps a few days to as long as three weeks.

Descent Rates

Haq's 1978 study on cocco-lithophores also helps us resolve a pressing creationist dilemma of whether to place the production of Cretaceous and Tertiary chalks within the Flood year (as the CEN Technical Journal proposes), before the Flood (as proposed by Woodmorappe), or shortly after the Flood (as suggested by Roth). The solution is obtained by considering the descent time of coccoliths through the water column. As soon as the coccolith-bearing organism dies, the platelets begin to detach and fall downward. Because the individual platelets are so minute and because they also sculptured with intricate cavities and perforations, they descend bottomward at an extremely slow pace. According to Haq[16] they take an

estimated 100 years for the 3000 to 5000 metre journey to the deep-sea ocean floor. Using the figure of 5000 metres which gives us a faster descent time, we can calculate that the average coccolith descends through a water column at a rate of 0.57 cm per hour. This rate can be verified in the laboratory, as my own research on coccoliths has proven to my satisfaction.[17]

The extremely slow descent rate for all coccoliths rules out the production of vast thicknesses of coccolith ooze during a one-year event, such as the Flood. Flood geologists estimate that if all the surface water on earth were spread smoothly over the earth, it would form a layer just under 3000 metres deep. To have a coccolith bloom in 3000 metres of water implies that it would take 60 years minimum for a chalk layer to form on the ocean floor, even if all 400 metres of coccolith ooze could be cultured in the one year of the Flood. Haq[18] points out that coccolithophores can grow only in the photic zone and are most abundant in the top 50 metres of the ocean. Flood-produced coccoliths would have to descend from the surface through a few thousand metres of ocean water to reach the bottom. If they were produced in the shallow continental shelf area, then sediments carried from the upland areas nearby would have clouded the waters, blocking sunlight and preventing production of coccoliths. Such could be produced only in the clearer and calmer waters of the deep ocean, if produced during the Flood. If produced above the continental shelves, then nearshore currents would tend to have kept the delicate coccoliths in suspension and to have further lengthened their descent time. The production of a 400 metre thick chalk layer exclusively during a one-year event cannot be adequately explained, either in the deep ocean where the descent rate is so minuscule, or over the shallow shelf regions where continental run-off sediments would have clouded the waters.

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Conclusions

Two options remain — most coccoliths in the fossil record were produced either after the Flood or before the Flood:

(1) The suggestion that coccoliths were produced after the Flood has the negative drawback that all deep-sea coccoliths would take about 5,000–20,000 years to form based upon today's rates, and all Cretaceous chalks found along the English Channel today would have taken approximately 20,000–80,000 years to form, if placed after the Flood. One would have to push the biblical Flood date back further and further in time.

(2) The proposal that most Tertiary and Cretaceous chalks were produced before the Flood is the more hypothetical of the two. Woodmorappe postulates that this would be possible because the antediluvian vapor canopy would have screened the deadly ultraviolet radiation that today inhibits coccolith production. The drawback to this is that it hinges on a hypothetical construct — the existence of an antediluvian vapor shield or canopy, which would have been a redundancy for a marine environment.[19] Nevertheless, a pre-Flood model for coccolith formation is the most plausible one in that we can more easily postulate higher production rates under the theoretically more ideal conditions before the Flood than what we find anywhere in today's world.

Whichever of the difficult options one chooses, one can profit greatly from Haq's informative report on cocco-lithophores. Your well-written **CEN Technical Journal** article asks a critical question in its title, 'Can Flood geology explain thick chalk layers?'[20] The answer is no longer 'Yes' unless one wishes to ignore the biblical data for a one-year Flood (Genesis 7:11; 8:13–14) and propose that the Flood extended over a period of decades if not centuries at least in central North America (especially Kansas) and in western Europe where we find vast thicknesses of relatively pure Cretaceous chalks.[21] Roth raises the crucial question in the title of his seminal article, 'Are millions of years required to produce biogenic sediments in the deep ocean?'[22] The answer to his question is still 'No'. While he demonstrates that coccolith oozes can be formed in much less time than what conventional geology estimates, his research can no longer serve as proof that coccolith production can be compressed into a time-frame of 6,000 to 10,000 years.

Warren H. Johns,
Berrien Springs, Michigan,
UNITED STATES OF AMERICA.

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7. Haq, Ref. 6, p. 85.

8. Haq, Ref. 6, p. 85.

9. Haq, Ref. 6, pp. 83–84.

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11. Westbroek, P., Young, J. R. and Linschooten, K., 1989. Coccolith production (biomineral-ization) in the marine alga *Emiliania huxleyi.* **Journal of Protozoology, 36**(4):368–373.

12. Westbroek *et al.,* Ref. 11, p. 371.

13. Haq, Ref. 6, p. 84.

14. Bold, H. C. and Wynne, M. J., 1985. **Introduction to the Algae**, 2nd edition, Prenctice-Hall, Englewood Cliffs, New Jersey, p. 422.
    Bold and Wynne state, *'the life history of* Emiliania huxleyi, *undoubtedly the most studied of the coccolithophores in regard to its physiology, remains somewhat uncertain, although patterns have been described. Three different cell types are recognized, each capable of indefinite vegetative reproduction: the coccolith-forming type (C cell), the completely naked cell type (N cell), and the scaly motile cell (S cell). Each of these three cell types reproduces asexually by simple constrictions.'*

15. Holligam, P. *et al.,* 1993. A biogeochemical study of the coccolithophore, *Emiliania huxleyi,* in the North Atlantic. **Global Biogeochemical Cycles, 7**(4):879–900.
    The bloom of June 1991 covered 250,000 km[2] and lasted about three weeks, indicating a coccolithophore longevity of perhaps 1–3 weeks.

16. Haq, Ref. 6, p. 100.

17. While enrolled as a graduate student at George Washington University, the author took the class Marine Micropaleontology, which had a section on coccoliths. Before observing coccoliths under the microscope, they had to be first separated from any other microfauna, such as foraminifera. A portion of deep-sea ooze is put into a small vial about 4 cm tall containing water, and the contents are shaken vigorously. The vial is left standing upright to allow the contents to settle. The heaviest specimens such as forams settle quickly. After 5 or 10 minutes only the most minute of the microfauna, consisting almost entirely of coccoliths, are left in suspension. At that point the coccoliths can be easily siphoned off for study under the electron microscope. A calculated coccolith settling rate of approximately 0.5 cm per hour is supported by our laboratory procedure, where there is negligible settling of coccoliths through a 3 cm water column in a period of just 5 or 10 minutes.

18. Haq, Ref. 6, p. 86.
    One recent study suggests that the cocco-lithophore *E. huxleyi* had its maximum growth 10–20 metres below the surface, not in the warmer surface waters. See:
    Paull, C. K. and Balch, W. M., 1994. Oxygen isotopic disequilibrium in coccolith carbonate from phytoplankton blooms. **Deep-Sea Research Part I, 41**:223–228.

19. The information in footnote 18 above has important implications, in that it raises the question whether an antediluvian vapor canopy is really necessary to protect coccolithophores from deadly ultraviolet radiation in order to reproduce rapidly. A 10–20 metre layer of sea water above the zone where coccolithophores most likely thrive would offer the same protection from ultraviolet rays as a vapor canopy, thus rendering the canopy redundant!

20. Snelling, Ref. 1.

21. P. A. Scholle, D. G. Bebout and C. H. Moore (eds), 1983. **Carbonate Depositional Environments**, American Association of Petroleum Geologists, Tulsa, Oklahoma, pp. 636–640.
    According to their data Kansas chalk deposits which contain at least 10 per cent clay are about 200 m in thickness, while European chalks which have less than one per cent clay can be found in some basins to have a thickness in excess of 1000 m, especially under the North

Sea. The amazing purity of the European chalk deposits argues against the idea that they could have been produced in a near-shore environment during a catastrophic event. The uplift of the Alps would have unloaded millions of cubic metres of sediment into ocean waters, thus blocking the sun's rays and thwarting production of coccolithophores, which are totally dependent upon the sun as their energy source.

22. Roth, Ref. 3.

The Author Replies . . .

We indeed appreciate Warren Johns raising additional important issues and supplying relevant data seemingly critical to determining how chalk layers in the geological record may have been formed within the biblical framework of earth history. We could therefore concede that calculation of turnover rates for coccolithophores needs to take into account their longevity, life cycle, productivity and timing of maturity, plus the descent rate of the coccoliths to the ocean floor. Furthermore, if we were to follow Warren's line of reasoning and accept his calculations as they are, then we would have to concede the conclusions he has reached, which are of course damning to the case I presented in my paper.[1]

However, neither of his two concluding options are workable within the biblical framework with its limited time-scale. There is absolutely no room within the chronological framework of Scripture to push the Flood back to 20,000–80,000 years bp so as to accommodate the formation of the chalk layers after the Flood. Likewise, to fit 20,000–80,000 or more years into the pre-Flood world so that the chalk layers may have been deposited then equally does violence to the scriptural record. Besides, if the chalk layers were pre-Flood, then the bulk of the fossil record would also be pre-Flood, and the geological record of the Flood must then only be found somewhere in the Tertiary and/or Quaternary deposits. Because those deposits are only minor by comparison to the vast bulk of the geological record, that option greatly reduces the scale and scope of the Flood geologically. Thus I reject both options,

in the first instance because they are untenable scripturally, and **I** feel sure that Warren Johns has the same misgivings.

So **I** believe we must look for the geological answers in directions other than those raised in Warren Johns' letter, because I still conclude that the chalk layers had to be deposited late in the Flood. The critical issue is both philosophical and geological, namely, is the present the key to the past? Put another way, are the calcareous oozes on today's ocean floors and the way they are forming today an accurate model for the formation of chalk layers in the past?

The Present is NOT the Key to the Past

The answer to both questions is categorically 'no', and the evidence most definitely confirms this emphatic conclusion. Neither *Emiliania huxleyi* nor *Coccolithus pelagicus* are found in the thick Cretaceous chalks,[2] so although it is legitimate to study the turnover rates, longevity, productivity, and descent rates, etc. of these present-day coccolithophores as Haq and others have done, such results cannot be automatically implied to represent the **same** parameters for **different** coccolithophores in the past. Thus the details presented by Johns are interesting and a potential guide, but we have no way of knowing for sure whether they are directly applicable. As he says,

> '. . . provided that present-day rates are valid for past periods. However, if Cretaceous waters were warmer, as all isotopic studies seem to indicate, the production time for Cretaceous coccolithophores could have been much faster than today's rates.'

Westbroek *et al.*[3] indicate that *E. huxleyi* can tolerate both elevated and reduced salinity, and temperatures ranging from less than 5°C to more than 30°C, while Haq[4] reports that within a temperature range of 18–24°C the optimum growth rate occurs and these algae grow almost four times as fast as at 7°C. Haq[5] also found that in laboratory cultures *Cricosphaera* sp. withstands salinities as high as 236 per

mil (the average salinity of open ocean water is only 35 per mil) during its non-motile or coccolith-producing stage. Thus it would appear that even today the parameters relevant to coccolithophore growth and turnover rates, productivity and longevity, are so highly variable that extrapolation back into the past cannot be relied upon alone to determine chalk formation rates. In any case, if chalk layers were deposited during the Flood they did so catastrophically under conditions that we cannot fully envisage, let alone reproduce today.

Johns would appear to have based his model for chalk formation on today's deep-sea sedimentary environment where calcareous oozes are forming, because a key component of his arguments is a descent rate based on a water depth of 3,000–5,000 metres. However, Ekdale and Bromley[6] make a clear distinction between deep-sea chalks and relatively shallow-water, shelf-sea chalks, the latter containing abundant megafossils, burrow flints and hardgrounds, common cyclicity of flint bands, hardgrounds and chalk-marl rhythms, common borings of particular ichnogenera, and common occurrence of pyrite, glauconite and/or phosphate minerals, all of which features characterise most of the European and North American chalk layers. Hancock insists,

> 'Of all aspects of chalk-sedimentation, the depth of the sea is the one that has attracted most discussion . . . (but) is a subject about which a fair amount of nonsense has been written.'[7]

Then after discussing the evidence presented in the literature, Hancock concludes, *'Therefore the intrinsic evidence is that white-chalk was deposited between about 100 and 600m',*[8] that is, deposited in relatively shallow water depths of between about 100 and 600 metres, not the 3,000–5,000 metres referred to by Johns. Indeed, if the deep-sea chalks are primarily well-documented in the deep-sea (DSDP) cores,[9] then this implies that these modern chalks on today's deep

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ocean floors are definitely **not** comparable to the white-chalk layers that were deposited in only relatively shallow water (100–600m) in the past but today are exposed on land. Thus the present is **not** the key to the past.

Deposition Features

The rate of deposition of these ancient chalk layers in question is of course interpreted in the literature without question on the basis of uniformitarian and evolutionary assumptions. Fossil dating is used to determine the length of time a chalk layer represents, and then the thickness of the chalk is divided by the time period to derive a deposition rate — typically 20–40 m per million years or 1–2 mm per 50 years.[10] But this scenario leaves uniformitarian geology with an intriguing dilemma — how could there be incredible stability of climate, deposition, erosion, etc. for 30 million years while 305–887 m of chalk was deposited over parts of England, today's North Sea area and across to Europe? Hancock says,

> '*Hence the extent of chalk over several continents for nearly thirty million years continuously. In north-west Europe the effect was heightened by a non-seasonal climate which suppressed erosion of the limited land that was left. Its purity is also explained by this peculiar palaeogeographic combination.*'[11]

However, in many places the chalk layers are rhythmically bedded, caused by rhythmic variation in the clay content, while there are regularly-spaced (about 0.5–2 m apart) joint-like breaks or bedding planes interpreted as small breaks in sedimentation ('omission surfaces')[12] and the occasional thin marl bands. This rhythmicity/cyclicity has been variously interpreted as reflecting changes in the supply of either the carbonate or clay, and/or changes in climate. Ditchfield and Marshall,[13] therefore, undertook detailed sampling at 2 cm intervals down such a rhythmically-bedded chalk-marl sequence in southeast England and found a cyclic variation in oxygen isotopic composition of the carbonate component. They concluded that these changes are most consistent with palaeotemperature fluctuations of up to 4.5°C, the chalk horizons being interpreted as representing periods of warmer temperature and higher primary productivity (of coccolithophores). Yet this is contrary to the uniformitarian model for chalk deposition which requires non-seasonal climate and incredible stability of climate for 30 million years!

Furthermore, Hancock reports that chalk pebbles occur in marls and marl-chalk junctions are cut by erosion hollows in some places; that the chalk ooze was not merely deposited in 'flat spreads', but was sometimes piled into heaps and banks up to 50 m high and 1.5 km in length accompanied by slumping; that smaller and less obvious carbonate banks with and without detectable cross-bedding are widespread in England; that submarine erosion surfaces are common in the chalks; and that some fine-grained chalks show a textural parallel lamination bedding.[14] All of these features cannot be the result of slow-and-gradual 1–2 mm per 50 years chalk deposition, or coccoliths gently sinking at a rate of 0.57 cm per hour taking 100 years to descend through 5,000 m of relatively still ocean water, as Johns would have it! On the contrary, rhythmic bedding, lamination bedding, submarine erosion surfaces, cross-bedding and enormous current-piled banks are all indicative of deposition involving rapid current flows.

Conclusions

So 'can Flood geology explain thick chalk layers?' The answer, I believe from the evidence on balance, is still 'yes'. Since most ancient thick chalk layers were deposited in 100–600 m deep water, vast algal blooms almost filling the entire water column would have been feasible. Productivity would have been increased by pulses of warmer water, as indicated by the oxygen isotope evidence, suggestive of a volcanic component that may well have also contributed nutrients. Furthermore, strong water currents and surges would have ensured more rapid deposition than mere gentle settling, but in any case the descent distance to the sea floor was minimal. The rapid removal and break-up of the maturer members of each algal bloom by the current surges would have assisted rapid regeneration of subsequent blooms in the nutrient-rich waters, thus ensuring a very rapid turnover rate and an abundant supply of coccoliths to be piled up in banks on the sea floor. The incredible purity of the thick chalk layers can only thus be guaranteed by such catastrophic processes over a very short time-scale, the evidence for which is the rhythmic and laminated bedding,[15] cross-bedding, erosion features and enormous current-piled banks.

While this Flood model for deposition of thick chalk layers is of course speculative because we are dealing with past catastrophic processes that today are not still operative, the evidence, including that discussed in my original paper, is far more consistent with it than with the slow-and-gradual scenario based solely on present processes in the open oceans and on their deep floors. Johns' data and discussion are a helpful guide, but the evidence within the chalk itself declares that the present is not the key to the past.

Dr Andrew Snelling,
Brisbane, Queensland,
AUSTRALIA.

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Woodmorappe Comments . . .

Johns has claimed that I have neglected the actual lifespan of coccoliths in my calculations. His charge is egregiously false. While it is true that I began my work by using Roth's data and assumptions, I then presented an episodic bloom model which **explicitly** allows for **only one lifespan** of coccoliths for the **entire duration** of the bloom:–

'This means one such bloom, on average, every 2.8 years in antediluvian times. Of course, these calculations are conservative even in that they assume that each massive bloom spawns only one generation of coccoliths.' (Emphasis in original.)[1]

Johns supposes that the average lifespan of a coccolith in a bloom is 12–50 days. In my episodic-bloom model, the average lifespan of a coccolith could, for all I care, approach 2.8 years, and the model would still be viable, thus compressing the generation of all the coccolith-bearing sedimentary rocks into an earth of only 6,000 years' age.

Let us, however, revisit the steady-state model. Johns' use of a 50-day average for coccoliths is purely conjectural. After all, one can hardly extrapolate the data from **one** coccolith to the great variety of coccoliths present in a bloom. However, for the sake of argument, let us imagine that it is valid. Even then, it would be true only of coccoliths limited in lifespan by endogenous factors. However, if blooms become poisoned through the 'red tide', or some other factor, the lifespan of their contained coccoliths is much less than the suggested 50 days (or even 12.5 days). Before the Flood, if there had been alternating factors in the antediluvian seas, blooms could have been killed off long before their postulated 50 day 'maturity', giving the space for new blooms to follow. If blooms had occurred during the Flood itself, as suggested by Dr Snelling, it is all the more likely that exogenous factors snuffed out the blooms long before their supposed 12–50-day lifespan. Thus the waters would not have been clogged by long-lasting blooms, and there would have been an intermittent but frequent 'rain' of dead coccoliths falling to the sea bottom.

Moreover, many if not most of the coccoliths which gave rise to the Cretaceous chalks are extinct, so we do not know, and will probably never know, their actual lifespan. This makes Johns' 50-day figure (amounting to a die-off of only 0.02/day) all the more baseless. However, we can do a sensitivity analysis, as shown in the ensuing paragraph.

What we need is not an average value for the lifespan of the coccoliths in a bloom, but a **weighted average** of the lifespans of the constituent coccoliths, expressed reciprocally as the die-off on a given day. Clearly, a value for an average lifespan of coccoliths in a bloom has little meaning because, as shown now, the calculations are **very sensitive** to even a small fraction of the coccoliths living only a few days or less. For instance, let us suppose that merely 10% of the coccoliths lived one day, and the other 90% lived 55.4 days (note that the average lifespan of a coccolith

remains 50 days). The daily turnover would be 0.118/day, which is less than the original steady-state prediction of 2.0/day (that is, a bidiurnal turnover), but is much higher than the 0.02/day gross-average value postulated by Johns. We can thus appreciate the significance of even a small, but non-trivial, percentage of coccoliths that live only a day or so. As for Johns' equally-arbitrary value of 12.5 days, let 10% of coccoliths live one day, and the other 90% live 13.78 days. The average would be 12.5 days, corresponding to 0.08 per day. But the **weighted** average becomes 0.165 per day and that assumes that **only** 10% of coccoliths live one day. Furthermore, there is evidence that some phytoplankton can not only multiply bidiurnally, but can be **replaced** bidiurnally.[2]

I now consider some other assertions by Johns. I am bemused to see him trot out the same old slow-sinking coccolith argument. In the reply section after my original work,[3] I pointed out that coccoliths sink much faster than predicted by theoretical settling velocities, owing to flocculation and other factors. His claim about light extinction is also false because, as I have dealt earlier with this hoary argument,[4] coccoliths are not as light-limited as once believed, and circulating water currents can bring coccoliths to within the photic zone for at least part of the day. Finally, certain coccoliths are saprophytic, and completely independent of sunlight.

As for sediments in water choking off the sunlight, most of the suspended sediment at the start of the Flood was probably underneath the photic zone and the coccoliths. This is especially true when we consider sediment transport through turbidity currents, which tend to hug the sea bottom. The 'amazing-purity' argument of chalk deposits is also false, because, as pointed out in my work, most chalk deposits are not all that pure. Moreover, if chalky sediment covered vast areas of the antediluvian seafloor, it must have been washed together into large thicknesses before there had come any significant influx of clastics to contaminate it.

Of course, in view of the fact that I have very generously made the problem much more difficult by assuming that all the Cretaceous carbonates are chalks, all the foregoing discussion is rather academic. Overall, it must be said that it does not appear that Johns has read my work too closely, as his arguments are not only fallacious but (in most cases) have already been dealt with in my original 1986 paper and the attached replies to the uniformitarians' criticisms. In conclusion, it remains, in fact, possible to reconcile the coccolith deposits with an earth of only several thousand years' age.

I would like to close by pointing out that all my works have recently been reprinted in a single volume: **Studies in Flood Geology,** by John Woodmorappe (1993). It is available from the Institute for Creation Research, PO Box 2667, El Cajon, California, 92021, United States of America for US$12.95 plus postage.

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DINOSAURS AND DRAGONS

Dear Editor,

D. (Lee) Niermann wrote about dinosaurs and dragons in **CEN Tech. J.**, 8(1):85–104. I very much agree with his conclusions and would like to add an interesting detail. When the Bible says in Job 40 about *behemoth* (which means literally a very large animal), *'He moveth his tail like a cedar: the sinews of his thighs are knit together'*, this can be interpreted as a special structure in the pelvic region of the large animal for the purpose of controlling tail movements. This type of extraordinary structure can only be found in dinosaurs (see Figure 1). It is incredible how exactly the Bible gives us the description of a dinosaur.
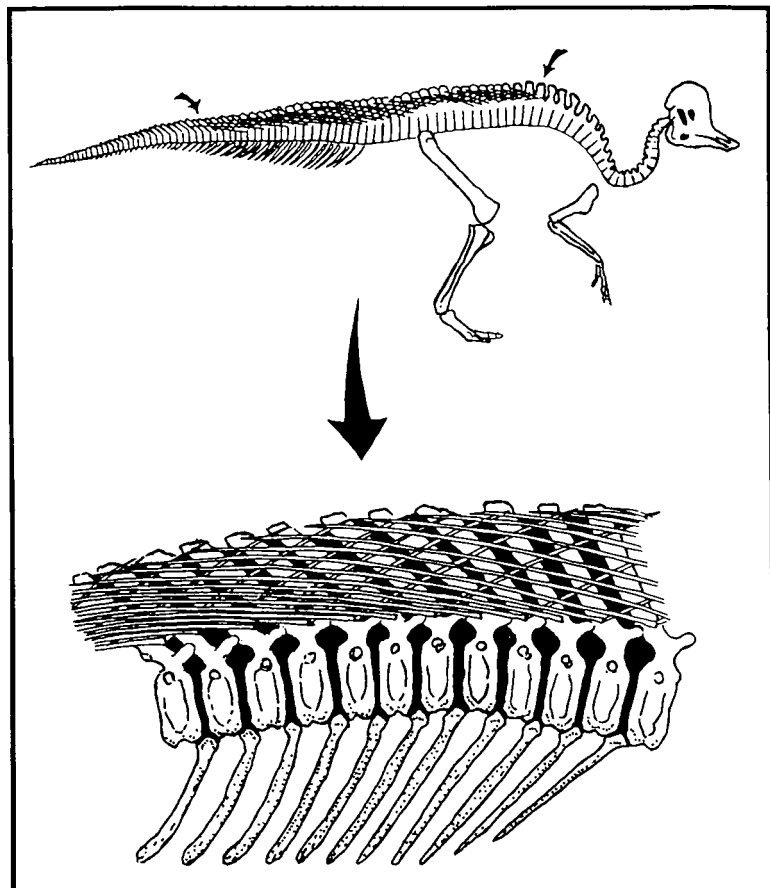
Pekka Reinikainen,
Helsinki,
FINLAND.

Figure 1. *Drawing of knit bony tendons which enable control of the giant tail of a* Corythosaurus *(from Bakker, R.,* **The Dinosaur Heresies***, p. 155).*

PUNCTUATED EQUILIBRIUM

Dear Editor,

I was quite disappointed in reading Don Batten's article[1] to realize that creationists still fail so miserably to understand punctuated equilibrium.

Punctuated Equilibrium Comments

It is extremely important for us as humans that, as we evaluate the writings of **others,** we carefully consider those writings in their context (as we must consider the context of biblical passages, the milieu of literary works,

etc.). In this light it is important to note that Eldredge and Gould's punctuated equilibrium model was birthed and defended in the context of the gradualist school of evolutionary theory. If this was adequately understood most of the misconceptions about punctuated equilibrium would (I believe) evaporate.

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