THE ANTEDILUVIAN BIOSPHERE AND ITS CAPABILITY OF SUPPLYING THE ENTIRE FOSSIL RECORD

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ABSTRACT

Relating quantifiable elements of the fossil record (coal and oil deposits, crinoidal limestones, Meso-Cenozoic chalks, Karroo Formation vertebrates, and biogenic components of carbonates) to the number (biomass) of their biologic progenitors at the time of the Flood. Anti-Creationist charges are proved specious.

INTRODUCTION

The Creationist-Diluvialist paradigm in its fullest development requires a young earth, with all biogenic manifestations in the earth's crust likewise confined to that time period. Certain anti-Creationists (1) and professing Creationists (2) have alleged certain difficulties with such a time compression. This work briefly examines these alleged difficulties, considering not only standing-crop biomass (2), but also biogenic accumulations in the 1656 years between the Creation and Flood.

COAL AND OIL DEPOSITS

A recent study (2) attempted to relate the total mass of organic carbon in coal and oil to that of the world at the inception of the Flood. Standing-crop phytomass was assumed to be the only source of organic carbon, and $5.25\text{x}10^4$ gms per sq. meter dry phytomass was the value quoted and used. It was concluded that the figures could be reconciled with a young earth only if most of the coal and oil was nonbiogenic in origin.

While considering only standing-crop phytomass, one should note that much higher values are possible. The greatest phytomass accumulations are not in the tropics (contra (2)) but in the U.S. Pacific Northwest (3). Using the factor .65 to convert live phytomass to dry matter (4), a value of $9.7\text{x}10^4$ gms per sq. meter is obtained (3) for sitka spruce/western hemlock stands. (Redwood forests, neglected here, can have values twice as high (3)). Log debris can provide an additional 38% dry matter. It must be stressed that none of the above cited values need approach those of the antediluvian biosphere: the maximal limit for standing-crop phytomass is unknown. Furthermore, many "virgin and primeval" forests of the type commonly used to estimate standing-crop maxima are now known (from discovered archeological remains) to have been cleared in historic times (4).

Far more serious than underestimating standing-crop phytomass, Morton's study (2) completely neglects the contribution of peat. As will now be shown, a significant accumulation of peat dwarfs any possibly-climax forest in terms of stored organic carbon. Using a factor of .45 (5) to convert dry phytomass to organic carbon (not .18 as erroneously used by Morton (2)), Morton's value of $5.25\text{x}10^4$ gms per sq. meter supplies $2.36\text{x}10^4$ gms per sq. meter carbon. My alternative value quoted above (dry phytomass and dry log mass; $13.5\text{x}10^4$ gms per sq. meter supplies $6.08\text{x}10^4$ gms per sq. meter carbon. By contrast, a mere cubic meter of peat supplies $11.6\text{x}10^4$ gms carbon (6), based on peat bulk density of 0.2 and 58% carbon content by mass. Contributions from standing-crop phytomass are henceforth neglected.

Since even a meter depth of peat supplies much organic carbon, it is worth considering plausible areal extent and thickness of antediluvian peat deposits. In 1656 years, peat deposits of 11.6 m depth result from the highest bog-plant productivities seen today (1,400 gms per sq. meter per year (7)), assuming no decay and peat density of .2 (6). Probably much higher productivities occurred in the antediluvian biosphere than even these maximal values because of favorable conditions. However, a major factor governing peat accumulation is its decomposition. The antediluvian earth was tropical, and tropical regions are inferior to temperate and boreal regions in terms of peat accumulation.

Nevertheless, tropical peats commonly occur in thicknesses exceeding 20m (7), indicating that the high temperature of the tropics is not necessarily the limiting factor in permanent peat accumulation. While growth of aerobic bacteria (and hence increased rate of decomposition) is favored by high temperatures, stagnant water-logged soils cause local reducing conditions and favor net peat accumulation. Extensive areas of stagnant water on the antediluvian earth were favored by the inferred low topography (Psalm 104:6-9), probable high water table (Gen. 2:6), and sluggish (i.e., closed loop) hydrological cycle (Gen. 2:5).

Consider coal. If, to start our calculations, we use the previously-discussed value of $1.16x10^5$ gms carbon per cu. meter peat and have the entire earth covered with 20m of it, $1.18x10^{21}$ gms carbon is available. Using Morton's (2) quoted value of $1.5x10^{19}$ gms carbon in all the world's coal, 1.27% of the earth's surface having 20m thick peat deposits is all that is necessary to supply the carbon. Moreover, there are smaller estimates of organic carbon in coal, but it is uncertain if the estimates refer to all coal or only to economically-usable coal. Sundquist (8) quotes values for coal as low as $5.38x10^{18}$ gms carbon, and only 0.46% of earth's surface with said peat deposits suffices.

Attention is now focused on oil. Consider Morton's (2) quoted value of $2.01x10^{20}$ gms carbon stored therein. Using the same 20m thickness of peat, 17% of the earth's area supplies global oil deposits (This, of course, assumes that peat is the sole source of organic carbon in oil. Marine sediments and their carbon will be considered shortly). As with coal, Morton's (2) quoted values for oil may be much too high. Bolin (9) proposed that only $5x10^{18}$ gms carbon is, as a lower value, found in the world's oil, coal, and gas put together. Again, it is uncertain if these totals include disseminated occurrences. If they do, then merely 0.42% of the earth's surface with 20m thick peat would supply the carbon.

Petroleum is thought to originate primarily from organic sludge in marine sediments rather than terrestrial peat. Shallow seas with poor circulation and reducing conditions accumulate sapropel. This could have served as an important source of organic carbon in the antediluvian earth, but it is difficult to quantify the contribution. A less concentrated but larger source of stored organic carbon is found in oceanic sediments. The present ocean floor contains $2x10^{22}$ gms carbon (10). If any combination of the carbon in the antediluvian oceans and that mobilized during the Flood totalled only 1% of the present oceanic amount, the high value (2) for global oil would be immediately satisfied.

This brief survey has shown that, even without nonbiogenic sources (2) of carbon, the total carbon stored in the worlds's coal and oil poses no problems for a young earth and global Flood.

CRINOIDAL LIMESTONES

Pelmatozoan debris is a very common constituent of carbonate rocks, and it has been alleged (2,11) that certain formations by themselves have more crinoids in them than could possibly have been alive on the entire earth at the same time. This subject must be approached by noting that only well-preserved (i.e., largely intact) crinoids found in rock must have been buried during the Flood itself. Highly fragmented crinoidal "hash" (and especially comminuted grains) could have resulted from crinoids that had lived long before the Flood. Each crinoid, when disarticulated, releases 30,000 to 50,000 plates of various sizes (12).

One must determine if certain limestones are actually crinoidal on a formation-wide scale. Clark and Stearn (cited in Morton (2)) allege that the Mission Canyon Limestone (Lower Carboniferous, western U.S.) consists of 41 thousand cubic km. of crinoid remains. An examination of the literature reveals that this is surely an exaggeration. Insoluble residue analyses (13) of several stratigraphic sections of Mission Canyon Limestone in Montana have revealed approx. 1% crinoid remains. A thin-section analysis of the same limestone from the same state has prompted the investigator (14) to describe fossil fragments as: "...ubiquitous but usually uncommon." In Wyoming, thin section analyses have shown that bioclastic debris occurs in a micritic matrix (15), while others (16) have, using whole-rock point counts, estimated at most 2% crinoid remains.

A more serious candidate for an extremely crinoidal limestone formation is the Burlington Limestone (Lower Carboniferous, central U.S.). Dott and Batten (11) have claimed that the Burlington Limestone, having a volume of $3x10^{12}$ m^3, consists of the remains of $2.8x10^{17}$ crinoid individuals. There are indeed horizons composed almost exclusively of crinoid remains (17). However, recent studies involving numerous thin-section analyses have shown an average of 50% crinoid composition for Burlington sections in central Missouri (18) and the north-central Mississippi valley (19).

Since volumes of crinoid debris generated are not limited to standing-crop of crinoids at the time of the Flood, an equation can express the total volume of crinoid debris generated in the 1656 years between the Creation and Flood:

$$V=1656DFTA \qquad (1)$$

(V) gives the total volume of crinoid debris generated, (D) is the density of living crinoids (individuals per m^2), (F) is the volume factor (i.e., volume of debris produced by one disarticulated crinoid individual), (T) is the turnover rate (no. of generations per year), (A) is the geographic area of antediluvian crinoid growth. (V) is set at 1.5x10^{12} m^3, which is 50% of the Burlington Limestone (i.e., the crinoidal part). (D) is 300 individuals per sq. meter (20). Such densities over large areas were probable for this reason: "The single most conspicuous feature of fossil occurrences of crinoids is a strong tendency for specimens to occur in close proximity to each other" (21).

Determining a value for (F) in Equation (1) requires scrutiny. (F) equals the reciprocal of the number of crinoid individuals required to generate a cubic meter of crinoid debris. Taking Dott and Batten's (11) estimates at face value implies 93,333 individuals per m^{-3}. This value is much too high; it would mean that each crinoid produces only 10.7 cm^3 of debris. Simple volumetric computations, treating each crinoid as a cylinder 65 cm. tall (the average height among some Lower Carboniferous crinoid stands (22) and 1 cm. diameter (commonly exceeded by Burlington crinoids (18)) argue for greaer debris production per crinoid individual. Indeed, Anderson's (12) estimates indicate 80 cm^3 per individual, so (F) in Equation (1) should be set at 8x10^{-5} m^3 debris per crinoid.

The turnover rate (T) is unkown for Paleozoic crinoids (20), hence estimates from extant types must be used. The turnover rate for modern echinoderms is 0.1-1.6 per year (23), with 0.2-0.3 per year the most common. Setting (T) at 0.2 per year and solving Equation (1) yields (A) equal to 189,000 km^2. This area thus supplies the Burlington Limestone with its crinoid content, and is only 2.4% of the area of the continental USA (in fact, it is less than the area of the Burlington Limestone itself). An alternative calculation, using the high turnover of 1.6 per year for (T), yields (A) equal to 23,650 km^2, which is a mere 16.5% of the area of the U.S. State of Iowa. It is evident that highly crinoidal limestones pose no problems for the young earth and the Flood. Furthermore, crinoidal limestones are not rated as highly abundant, in the Paleozoic at least (24), making it all the more unlikely that they should elsewhere be problematic for Creationists.

In fact, if anything, arguments about crinoidal limestones can be turned around. It is uniformitarianism, not Diluvialism, that has problems accounting for them. Boucot (24) wrote:

> **It is obvious that crinoidal limestone forming today is relatively rare, even in the tropical regions where crinoids tend to be more abundant and have a better opportunity for preservation than in colder waters.**

In a similar vein, Carozzi and Gerber (25) wrote:

> **Little is known about the Late Paleozoic ecological conditions that allowed for very large areas of coarse-grained crinoidal deposition in moderately agitated, clear, and well-aerated water. No modern analogs of these occurrences are known.**

These features bespeak not only failure of uniformitarian theory and methodology, but also an antediluvian earth very different from the present one. Furthermore, the Burlington Limestone itself shows evidences of Flood deposition. Alternating layers of crinoidal debris indicate high-energy depositional events (19,25). There are also evidences of rapid, slurry-type deposition: gravity-driven mass movements and crinoidal turbidites (18). Most intriguing of all is a shattered chert-breccia horizon in the Burlington (19). This graded-bedded horizon is attributed to a tornado-like event by Gerber (19).

MESO-CENOZOIC CHALKS

Chalks are a form of limestone composed primarily of micro-organisms, especially coccoliths (26). Although coccoliths are known since Jurassic (26), chalks do not become prominent until their explosive development in Late Cretaceous and (to a lesser extent) Tertiary. At present, coccoliths accumulate on the ocean floor, and Roth (27) has shown that such deposits could have accumulated in only 200 years. Returning to Meso-Cenozoic chalks, it has been alleged (2) that they are a problem for Flood geology, yet no calculations had been performed.

Since it is Late Cretaceous and Tertiary that are of relevance, one must determine the total volume of chalks from those geologic periods. Such information appears to be unavailable, but one can begin with the extreme (and therefore conservative) assumption that all Late Cretaceous and Tertiary carbonates are chalks. Of course, they are not, and even individual formations that are mapped as chalks need not be. In a recent study involving Late Cretaceous rock, Frey and Bromley (28) wrote:

> **Purer chalks crop out only in a relatively small area of Western Alabama and adjacent parts of northeastern Mississippi (and are not uniformly present even within this small area), yet the term has been used both colloquially and in a formal rock-stratigraphic sense well beyond these occurrences.**

There are 17.5 million km^3 of Late Cretaceous and Tertiary limestones (29-31) and all the calculations herein are based on the said extreme assumption that they are all chalks. Existing estimates (32) for chalk accumulation rates can't be used because they rely on uniformitarian methodology that has no meaning in the Creationist-Diluvialist paradigm. Direct productivity estimates must be used. Using Roth's (27) calculations (which deduce 100m thicknesses of coccoliths per 200 years), one would need 21.1 million km^2 (i.e., 4.1% of earth's surface) of coccolith-productive seas to supply the 17.5 million km^3 of coccoliths in 1656 yars.

Alternate calculations, performed by the present author, follow. The larger coccoliths have diameters of 0.04 mm (36), smaller ones are more common but can reproduce at faster rates (35-36). Each 0.04 mm diameter coccolith has a volume of 3.35×10^{-14} m^3, so there are 2.99×10^{13} coccoliths per m^3. This is an exaggerated number because zero void space is assumed. In reality, coccoliths in chalks are loosely packed, as indicated by chalk's high porosity (33), and its density being commonly half that of other limestones (34).

It is difficult to model the productivity of coccoliths because coccolith concentrations in water vary in space and time by orders of magnitude. One can start by allowing each m^2 column of water to contain a conservative 3.5×10^{11} coccoliths in suspension. This situation is realized, for example, by having 35 million cells per liter (as sometimes seen today (35)) to a very conservative depth of 10m, or a very conservative concentration of 700,000 cells per liter to depths of 500m (commonly exceeded today by great densities of coccoliths (35)). A bidiurnal turnover rate for coccoliths can occur (36) though even greater rates can occur for smaller coccoliths (35-36). There are 1.2 million turnovers in 1656 years. At the said exaggerated value of 2.99×10^{13} coccoliths per cu. meter, a 1.4 km thick column is produced (i.e., 4.23×10^{17} cocoliths per m^2 column). Taking the said exaggerated necessity of 17.5 million km^3 of coccoliths (i.e., 5.23×10^{29} cells), a 12.5 million km^2 area (merely 2.5% of earth's area) suffices.

An alternative model of coccolith accumulation is now presented in order to reflect the fact that coccolith accumulation is not steady-state but highly episodic. There are intense blooms of coccoliths, and these can cause "white water" (36) situations because of the coccolith concentrations. Approximately 10% of earth's surface underlies, and is able to have supplied, marine Late Cretaceous and Tertiary (see Maps 32 and 34 of my work (39). If each bloom covers 10% of the earth's surface to a water depth of 500m and generates 35 million cells per liter, 8.93×10^{26} coccoliths are spawned per bloom. Roughly 588 such blooms are needed to produce the highly exaggerated 5.23×10^{29} coccoliths required. 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.

It must be noted that neither water depths of 500m nor concentrations of 35 million cells per liter need be limiting factors. The anti-Creationist Schadewald (1) lambasted Creationists by ascertaining that thermodynamic considerations prevent a much larger biomass on earth than at present. He is clearly wrong: Tappan (37) has recently noted that oceanic productivities 5-10 times greater than present could be supported by the available sunlight, and it is nutrient availability (especially nitrogen) that is the limiting factor. Present levels of solar ultraviolet radiation inhibit marine planktonic productivity (38,40). If the antediluvian canopy screened out most or all of this injurious ultraviolet light, all the higher oceanic productivities could have been sustained.

KARROO FORMATION VERTEBRATES

The Karroo Formation (Permo-Triassic of South Africa) is said to contain the remains of 800 billion vertebrates (1). None of the references cited in (1), or elsewhere, allow a determination of how this value was calculated. Schadewald (1) has scurrilously denounced Creationists as pseudoscientists for allegedly ignoring population densities. He asserted the supposed impossibility of such large simultaneously living populations (8.5 per hectare for Karroo fauna spread globally, 851 per hectare if Karroo contains 1% of all fossil vertebrates). It is easy to show the absurdity of Schadwald's arguments, and that it is he who is the pseudoscientist that has not "done his homework."

A population density of 800 per hectare results if the supposed 800 billion Karroo vertebrates are evenly spread over Africa south of the Equator (i.e., 10 million km^2 area). Compare this "impossible" density with known densities (in individuals per hectare) of some modern reptiles: 889 (1.6 kg. iguanid lizards), few thousand to 110,000 (anoles and other small lizards), 548 (Colubrid snakes), 10,000 (Manchuria island pit viper), 1235 (Colorado rattlesnakes), 480 (the rhyncocephalian Tuatara), 570 (pond turtles). The first six citations are from Turner (41); the seventh is from Bury (42). It should be noted that the above-cited populations are actual habitat (as opposed to migratory) populations. Furthermore, the population densities occur over significant, even if localized, areas, and are not merely highly-provincial pockets of high population density. Although a full-fledged study of population densities of all types of animals is beyond the scope of this work, it can be seen that small areas can support large numbers of animals.

Even reptiles significantly larger than most Karroo reptiles can have surprisingly high population densities. The giant tortoise Geochelone gigantea (130-300 kg. males; 1-1.5m length) reaches population densities up to 160 per hectare (45) on Aldabra Island. Among dinosaurs, ceratopsians are believed to have attained densities of 28 km^{-2}, and hadrosaurids 51 km^{-2} (46). Most of the Karroo reptiles (i.e., of the Lystrosaurus and Cistecephalus zones) appear to have been primarily in the size range of 0.3-0.7m in length (47). Compared to the reptiles cited above, the Karroo reptiles appear to most closely compare to Tuatara (.41-.66m long; 2 kg. weight (48)), and the 1.6 kg. iguanid lizards. The quoted population densities for the said living reptiles (480 and 889) are within the range of that required (800 per hectare) to support the supposed 800 billion Karroo vertebrates in southern Africa.

Furthermore, Schadewald (1) is completely wrong in fingering thermodynamic considerations as limiting factors in population density. For autotrophs, sunlight is not the limiting factor in their productivity (56): nutrients commonly are. Among animals, structural complexity of the environment is a very important factor in population density (41, and low predation rates, also important (43-44), may be even more so than tropical plant productivity (43). In the antediluvian world, environments probably were more complex, and soils more nutrient-rich, than any extant environment. If man's license to eat meat after the Flood (Gen. 9:2-4) reflects wholesale increase in predator-prey ratios over those of antediluvian times, animal population densities at the time of the Flood could have been much higher than even the high values quoted above. Yet even without these additional considerations, it is evident that arguments against the Creationist-Diluvialist paradigm based on population densities (1) are completely fallacious. The Karroo fauna iself needs little space.

BIOGENIC COMPONENTS OF CARBONATES

The biologic productivities needed to supply crinoidal limestones and chalks have already been discussed. This section considers limestones as a whole without any special consideration for type of limestone. The organic carbon in the earth's carbonate rocks has been said to be a problem (2) for Creationists. The first consideration to be made is whether or not carbonates are entirely organic in origin. Grain-sized constituents of limestones are demonstrably organic in origin, and conventional petrographic microscopes can be used to identify the organisms producing the skeletal material. However, most limestones are micrites (49), and most micrites are indefinite as to their origin (50). Some studies involving electron microscopy (50) indicate that many micrites are likewise of biogenic origin (i.e., especially highly-comminuted skeletal material). We can begin our calculations with the extreme assumption that all limestones are of biogenic origin, although primordial $CaCO_3$ will be briefly considered later. Highly productive marine regions today have productivities of 10^5 gms per sq. meter per year

$CaCO_3$ (51). Individual types of corals can have productivities exceeding that number, while most other marine biota (green algae, red algae, molluscs, echinoderms, and forams) have productivities of 10^4 gms per sq. meter per year $CaCO_3$ (51). However, when it is remembered that productivities 10 times those of present can be sustained by suitable nutrients (37), an overall $CaCO_3$ productivity of 10^6 gms per sq. meter per year can be attained.

If the entire earth had a productivity of 10^6 gms per sq. meter per year for 1656 years, 8.45×10^{23} g $CaCO_3$ would have been produced. Using a factor of 0.12 for organic carbon, 1.01×10^{23} g carbon would have been produced in carbonate rock. Consider Morton's (2) estimate of 6.42×10^{22} g carbon in earth's carbonates. Thus, 63.6% of earth's surface with said productivity would suffice to supply the carbon. But Morton's (2) values may be too high. Valiela (40) has quoted 1.83×10^{22}g carbon in limestones. Thus, 18.1% of earth's area then becomes sufficient. Even lower is Usdowski's (52) estimate of 8.4×10^{21}g carbon, for which only 8.27% of earth's area would have sufficed.

Of course, the foregoing calculations assume that 100% of carbonates have been secreted by organisms. Some disseminated as well as concentrated CaCO3 may have been built-in to the antedulivian regolith since the Creation as filler material, and then have become reworked by Flood action. Calcium in soil is an important nutrient derived from $CaCO_3$, and high levels of calcium in ground water correlate with reduced incidence of dental caries (53). This nutrient role is probably another reason why the Creator most probably created some primordial CaCO3. Another important source of nonbiogenic carbonate is chemical precipitation. Inorganic precipitation must have taken place alongside organic precipitation, as it does today (54). Much chemically-precipitated CaCO3 must also have been generated during the Flood itself, as waters with different ions were constantly mixed.

OTHER CONSIDERATIONS: MARINE FOSSILS

Schadewald (1) has asserted that there are far too many marine fossils in rock to have been all alive simultaneously, but presented no calculations or other evidences to support his contentions. The present author has diligently attempted, by research and contact with paleontologists, to arrive at a figure for average concentration of fossils in earth's rocks. No such information is available, and estimates are exceedingly difficult to make because concentrations of fossils vary in strata, and geographic regions, by many orders of magnitude.

Nevertheless, there certainly is no basis for Schadewald's (1) arbitrary figure of 0.1% fossil content in rock. A concentration of 0.1% implies a 10 cm^2 fossil per m^2 of outcrop face. The overwhelming majority of sedimentary rocks have far, far lower abundances of fossils, so the average for all earth's sedimentary rocks must be magnitudes lower than 0.1%. The rarity of fossils as a whole is well described by the eminent paleontologist Simpson (55):

> **In spite of such exceptional examples, the great majority of fossils are found embedded in, or recently eroded from, exposures of sedimentary rocks. Yet one could dig at random in exposures of such rocks for a lifetime without encouraging a single fossil. The first discovery of an area or a stratum in which fossils of a given sort are present is often made by chance or serendipitously by someone who was looking for something else—but almost necessarily by someone who knows a fossil when he sees one... A paleontologist on the prowl for fossils often looks as if he were trying to find a dime that he had accidentally dropped somewhere in a hundred square miles or so of badlands.**

A suggested average abundance of 0.1% for fossils is clearly ridiculous. Nevertheless, the present author plans to continue his research on fossil abundances in order to one day provide an average and then compare it with possible live biovolume at the time of the Flood.

CONCLUSIONS

It is evident that the alleged problems cited (1,2) for Scientific Creationists are not problems at all. Including live Karroo biota, biogenic materials accumulated before the Flood (and then re-deposited during the Flood) is more than sufficient to supply the fossil record. In fact, many if the arguments advanced in (1) and (2) seem more devoted to the discrediting of Creationism than a study of it. Nevertheless, the Creationist-Diluvialist paradigm only grows stronger as it passes ostensible falsification tests.

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DISCUSSION

It seems that only the very fastest rates observed today and only the very lowest estimates of carbon content are used for Mr. Woodmorappe's calculations. This is close to special pleading. For instance, Bolin's estimate of carbon in petroleum, coal, and gas is used. Mr. Woodmorappe is uncertain as to whether Bolin's estimate includes disseminated occurrences, but he goes ahead and assumes that it does. Hunt's value of organic carbon in coal, oil, and gas which was used by Morton definitely does include disseminated occurrences. Even though Bolin stated that his value was a lower limit, Mr. Woodmorappe uses it as if it were an upper limit.

Mr. Woodmorappe also uses the rate of production of 35 million coccoliths per liter as his average production rate of chalk. Rates of dinoflagellate production as great as this are found only for very short periods of time over very limited areas. The occurrences are known as red tides; and due to the massive use of oxygen in waters infested with such numbers or microorganisms, all fish in the area die. Eventualy even the microscopic animals die from too much crowding and not enough food and CO_2*. To assume that such concentrations could occur for 1656 years ignores the fact that we do not see endemic populations like this today. Mr. Woodmorappe, when discussing limestone production, uses a rate of limestone formation which is ten times that observed today; and he has the entire ocean and land areas producing limestone at these accelerated rates.*

Glenn R. Morton, Ph.D.
Dallas, Texas

Mr. Woodmorappe's 17.5 million km^3 *of Late Cretaceous and Tertiary limestone would cover the earth to a depth of 34 meters. If only 1% of it is skeletal limestone, that represents enough marine creatures to cover the earth to the depth of a foot. He ignores the Price/Morris Flood scenario, which attributes fossils to animals that died in the Flood, and uses his new rules to stockpile marine fossils (e.g., coccoliths) for 1656 years. But his chalks overlie proterozoic, paleozoic, and/or earlier mesozoic strata supposedly laid down by the Flood. Thus, he must stash his accumulated coccoliths somewhere for most of the Flood and then transport and deposit them, often without contamination by other materials.*

Robert J. Schadewald
Minneapolis, Minnesota

Mr. Woodmorappe has supplied the initial calculations on a very much needed study. Proper and careful consideration of this problem may lead to more than just a refutation of anti-creationist arguments. We may be able to reconstruct the biota existent at the time of the flood's initiation, as well as the geologic processes which occurred in the antediluvian world.

An extremely important factor to be considered here, however, is taphonomy. All calculations assume no decomposition over 1656 years. Taphonomic studies of Flessa and others need to be taken into account.

Kurt P. Wise
Framingham, Massachusetts

CLOSURE

These replies are not only to the authors of the written comments, but also to the oral criticisms (on tape). Because of space limitations, the critics' written comments have been shortened. My responses here are to the original critical paragraphs. The critics are answered by author and (because there is much overlap in arguments from different authors) some by argument.

I thank Mr. Wise for his comments. True, this paper did not consider taphonomy. Nevertheless, even if one allows some factor such as 50% to account for decomposition, the conclusions of this paper are unchanged.

Glenn Morton's statement about my use of Bolin's data is so obviously untrue that one of two conclusions is forced: Mr. Morton hasn't really read my paper, or he is deliberately misrepresenting my paper. I have considered not only Bolin's but also Hunt's higher values. If anyone is engaging in special pleading, it is Mr. Morton (because of his use of only Hunt's estimates--which are high--in his original paper). As for use of fastest rates today, their use is fully justified. Since the present world has many limiting factors not present in the antediluvian earth, there is no reason why one should be constrained by today's average values. The fastest rates today could easily have been the norm in antediluvian times. Furthermore, as discussed in my original paper, there are grounds for suspecting that the antediluvian rates were even higher than the highest contemporary rates. Also, my calculations were conservative in many ways (as, for instance, assuming that all Late Cretaceous and Tertiary carbonates are nothing but chalk).

The deaths of fish, etc., during blooms is irrelevant. However, not all blooms contain poison-secreting microorganisms that cause mass death(1). (Further consideration of arguments against massive blooms is presented below.) As for use of ten times present rates of carbonate accumulation, this has been discussed and has already been substantiated by the fact that 10 times greater oceanic productivities can be sustained with proper nutrients (Tappan, ref. 37, original paper).

Mr. Schadewald's oral criticisms about limiting factors show a continuing misunderstanding of them. Factors like sunlight and thermodynamics are only ultimate limiting factors. The factors that I vary nowhere approach these ultimate limiting factors.

The mammals that Schadewald cites in the Karroo Formation are a minority compared to the reptiles. Nevertheless, the mammals therein could easily have been within the population-density range of 850 per hectare for reptiles. The Mesozoic mammals are all small rodent size (10-100 grams(2)). Mammals that size today commonly reach population densities of 200 per hectare(3), with some rodents up to 500 per hectare(4), and voles at the apex of boom-crash cycles at 1000 per hectare(5).

My use of antediluvian accumulations is only a very minor modification of the Price-Morris Flood scenario. The purity of chalks is discussed below, and the reason why they overlie earlier Flood-deposited strata is straightforward. As expounded upon in an earlier work (ref. 39, original paper), TABs (Tectonically-Associated Biological Provinces) explain the stratigraphic separation of faunas.

Concerning Peat Accumulation

In his oral criticism, Francis Graham dismissed my model as a "marvellous Rube Goldberg machine." On the contrary--Graham is completely wrong in his remarks. He asked where in historic times has 20 meters of peat accumulated. It's so simple-- British peat bogs have accumulation rates up to 0.98 cm. per year(6), which comes out to 16.23 meters in 1656 years. The average for North American peat bogs is half the figure above. Far from being a Rube Goldberg machine, 20 meters of peat in antediluvian times may have been very conservative.

Mr. Graham's arguments about sunlight on leaves and plant spacing limitations are nonsense. It is pointless to quibble about something on vague theoretical grounds when one can observe the requisite phytomass densities and can observe the requisite peat accumulation rates.

As to inorganic origins of coal and oil, the moderator cited the lecture of Thomas Gold. Indeed, Gold(7) has recently published about it.

Coccolith Blooms and Chalk Accumulation Rates

My critics seemingly struggled in order to outdo each other in their adherence to uniformitarian assumptions and present-day rates. Wonderly's book(8) should appropriately be retitled: Uniformitarian Imaginations'--Certainly Not God's--"Time Records" in Ancient Sediments.

Consider the present millimeter-per-millennium accumulation rates of abyssal calcareous oozes (cited by Wonderly). They are completely irrelevant to this discussion. Concerning oceanic waters, Goldman et al(9) wrote: "...there is overwhelming evidence that nutrients in these waters are in short supply, and are often undetectable... Cells assimilate the limiting nutrient and grow to a specific population size." Elsewhere, Rhyther(10) has shown that 90% of the ocean surface is so unproductive that it should be considered a biological desert. Rhyther's figures show that, in times of active upwelling (hence nutrient flux), the ocean surface there can produce more in a day than most of the ocean does in an entire year.

Let's apply this knowledge to the arguments of Wonderly and Morton. Since 90% of the ocean is a biological desert, it is no wonder that abyssal oozes accumulate at only millimeter-per-millennium rates. It is as fallacious to use these meager rates to model coccolith productivities as it would be to use sparse and widely-separated cactuses to model possible land phytomass productivities. My model of extensive blooms is no more a Rube Goldberg machine (remark about these blooms by Francis Graham) than would be a tropical jungle when not falsely limited to the productivity and phytomass accumulation of a nearly barren desert.

Messrs. Morton and Wonderly belabor the fact that Blooms today are only temporary and over a limited area. Why of course they are--today--just as any places of lush vegetation in a land desert would be localized, rare, and temporary. What today is rare and local in the ocean could easily have been the norm in the antediluvian seas.

The Self-Destruction of Large Blooms

Blooms indeed are eventually self-destructive, which is why I presented an episodic bloom model. However, nutrients and oxygen are not as promptly depleted as Messrs. Graham, Morton, and Wonderly imply. This is because neither sea water nor many of the plankters are passive. Holligan et al(11) have noted that wave mixing by internal waves delivers nutrients to nutrient-depleted surface layers. Indeed, the very persistence of present-day blooms led him to this conclusion. Also, many of the plankters themselves can migrate temporarily to deeper nutrient-rich layers(12).

Arguments about sunlight extinction (Graham, Wonderly) are also fallacious. Since, as the previous paragraph showed, both waters and many plankter individuals move vertically, many more plankters can be exposed to sufficient sunlight than those present at any one time in the photic zone. The 500 meter depth is well-documented (ref. 35, original paper). Moreover, recent evidence shows that phytoplankton is not as light-limited as has been believed. Whereas it had been long thought that phytoplankton cannot function below a 90%-99% sunlight extinction, recent evidence presented by Little, et al(13) indicates that phytoplankton can flourish even at 99.95% sunlight extinction. Very heavy plankton blooms can reduce sunlight transmittance by as much as 50% per meter of water(14), so the 99.95% sunlight extinction is not reached until a depth of 11 meters. Thus Mr. Graham is completely wrong about the 10 meter depth being excessive. Moreover, not all coccoliths are autotrophic. There are saprophytic coccoliths that exist down to 4000 meters depth(15). My original calculations are thus very conservative because they assume that saprophytic coccoliths don't exist at all.

Coccolith Sinking Rates and Dissolution in Undersaturated Water

These are two old chestnuts that Wonderly trots out. Arguments about dissolution and undersaturated water fully apply to deep oceans but only slightly to shallow sea water(16). If shallow antediluvian seas had very high productivities (as followed here throughout) they were probably always supersaturated.

Mr. Wonderly's argument about sinking coccoliths is nonsense. Numerous observations(17) have demonstrated that microscopic cells sink at much faster rates than predicted by theoretical settling velocities. Nor are we limited to transport via fecal pellets, or to flocculation. Billett, et al(17) have demonstrated that phytoplankton sink in large (often strand-shaped) gelatinous aggregations.

The "Problem" of Pure Chalks

In his book(8) Mr. Wonderly has imagined that the purity of chalks demonstrates that they must have been formed in very quiet sea water undisturbed by currents. Mr. Wonderly's view is not even shared by his fellow uniformitarians. The famous European Chalks show numerous evidence of post-depositional transport, and therefore Eckdale, et al(18) have recognized many chalks as being allochtonic.

Since depth of Floodwater (perhaps hundreds of meters) is small compared to its area, whatever turbulence it had should not invariably have caused mixing of chalk with terrigenous materials. Thus turbulence in Floodwater must have been primarily vertical, and source-area effects must have been the primary determinants of eventual rock composition. As is, many (if not most) chalks are not particularly pure(19) and many coccoliths are not even found in chalks.

Origin of Carbonates As a Whole

Mr. Wonderly's assertion that nearly all limestones are proveably of organic origin is false. This uniformitarian belief stems from actualistic analogies with modern carbonate environments and is not based on petrographic analyses. Indeed, it is usually impossible to determine the origin of micrite(20) and, as shown in my original paper, most carbonates are micrites.

Fossils As a Whole

I would trust the remarks of the eminent, late, paleontologist Simpson over those of Wonderly any day. Mr. Wonderly's claim of many more fossils originally is based not on evidence but on his uniformitarian preconceptions. As for microfossils, they are usually present in most rocks, but rarely in great amounts (i.e., relative to the volume of the rock itself).

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