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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh. —Exodus 20:11

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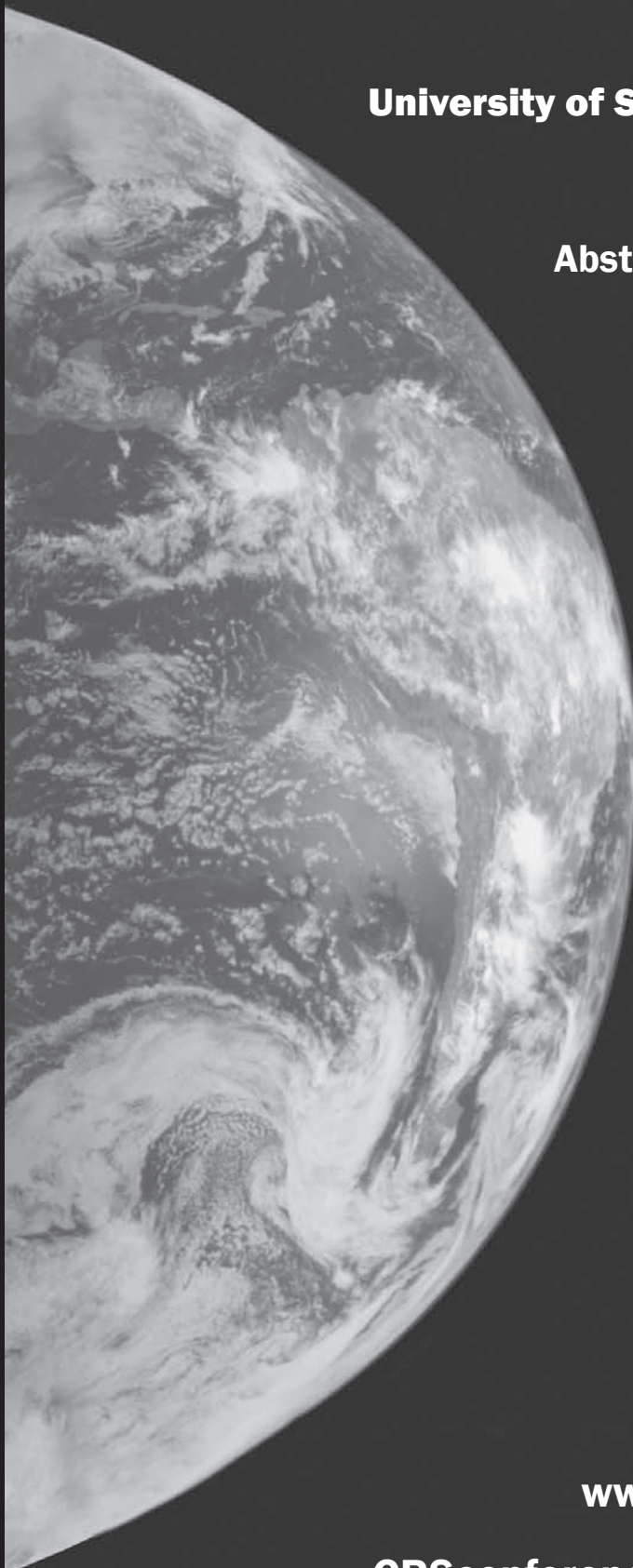
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Editorial

One Hand Clapping

The political novelist George Orwell once wrote, “If liberty means anything at all it means the right to tell people what they do not want to hear” (Orwell, 1972). He continued by suggesting that “the common people still vaguely subscribe to that doctrine” but all too often “it is the liberals who fear liberty and the intellectuals who want to do dirt on the intellect” (Orwell, 1972). These comments are as relevant now as when they were first written over half a century ago. Certainly, we can see this happening in a number of so-called intellectual circles, not the least of which is the scientific community.

Evolutionists have long argued that creation is clearly not science because creation-related papers are not published in scientific journals. The strategy is fairly obvious; if creation science (or even intelligent design [ID]) can be marginalized as “unscientific,” then its arguments can be totally ignored. This makes for a rather convenient escape, especially considering that evolutionists often struggle to deal with the scientific specifics during a debate against a competent creationist. So, the adage would seem to be, “if you can’t beat them, ignore them.”

While it would seem that the case of the Stephen Meyer paper would be the final proof that there is an intentional barrier to publishing a pro-creation/ID article (Klinghoffer, 2005), evolutionists have engaged in an all-too-predictable façade of blame game, denial, and claims of “right-wing” conspiracy. They

are certainly not going to acknowledge that they immediately and intentionally reject any and all pro-creation or pro-ID papers with little regard to scientific content. (Of course they will argue that if it is pro-creation it cannot possibly possess any scientific content, which actually proves their prejudicial treatment.) The simple truth of the matter is that Dr. Meyer’s ID paper passed through the normal peer-review process and was published. Since this apparently violated an unwritten rule (actually, maybe it is written somewhere), the evolutionary establishment was furious. How could they continue to hide behind the safety of “no published papers” if a pro-creation/ID paper actually got published?

Who are the “they”? Evolutionists often mockingly suggest that creationists have a conspiracy-theory complex, causing them to vaguely refer to some mythical “they” controlling the science journals, meetings, etc. Evolutionists instead will insist that there is no conspiracy against creationists. The poor evolutionist is just humbly seeking the best understanding of scientific data and principles humanly possible. Creationist papers would get published if they were any good, so don’t blame them for the simple fact that creationist papers are just not very good.

But consider this. In 1998, the National Academy of Sciences (NAS) published a booklet zealously promoting the teaching of evolution in schools. In this booklet the NAS advocates that evolution is “the most important concept in

modern biology” (NAS, 1998, p. 8). The NAS purports to represent the elite of the scientific community, and membership is a very prestigious honor. As such, the NAS is often viewed as the pulse or the voice of the scientific community. If their “official” position is that evolution is an essential component of biological science, then it is difficult to see how they would not use their influence to block any attempts to reduce evolution’s status (including opposing publication of papers with an antievolution or pro-creation tone).

The American Association for the Advancement of Science (AAAS) is

The strategy is fairly obvious; if creation science (or even Intelligent Design) can be marginalized as “unscientific,” then its arguments can be totally ignored.

the largest scientific organization in the world. Among AAAS's activities is Project 2061, a so-called educational agenda whose primary purpose seems to be advancing the teaching of evolution. The AAAS board of directors has passed an anti-intelligent design resolution (<http://www.aaas.org/news/releases/2002/1106id2.shtml>), and the AAAS provides numerous pro-evolution/anticreation resources (http://www.aaas.org/news/press_room/evolution/). They also publish the journal *Science*, considered one of the most prestigious scientific publications. It would seem extremely inconsistent, therefore, for AAAS publications or policies to even consider creation science as a potential alternative to evolution. Could creation science receive an objective and fair "hearing" from the governing body of AAAS or its journal's editorial board? Only extreme naiveté (or intentional deception) would allow someone to think that it could.

Nature, another very prestigious science publication, has honored Paul Myers's vehemently anti-god, anticreation blog, *Pharyngula*, as a top five science blog (<http://www.nature.com/news/2006/060703/full/442009a.html>). Does anyone seriously think that creation science papers could receive an objective evaluation from a journal that honors Myers's writings? While it was being published, the journal *Science and Theology News* promoted itself as a mixing ground of scientific and religious thought. Yet, in its July/August, 2002 issue, the editor declared that any young-earth creation articles would be unceremoniously rejected (i.e., they would never even be considered), and despite normal policy of allowing authors to respond to negative book reviews, creationists would receive no such opportunity. In rejecting an ID paper submitted by noted intelligent design advocate, Dr. Michael Behe, the editor of one biology journal flatly stated that his journal supports a strong evolutionary

position and that positions opposing that view will not be published (<http://www.discovery.org/scripts/viewDB/index.php?command=view&id=1212>).

In the face of all this, can creationists (and even ID proponents) have any alternative but to conclude that their manuscripts are intentionally and systematically being singled out for exclusion? Show me where intentional exclusion is *not* occurring in the scientific literature.

In response, many evolutionists then seek another refuge by claiming that the extreme unpopularity of creation science within the scientific community clearly demonstrates it is not scientific. If it were really scientific, it would not be so unpopular. I never realized that scientific truth was based on a popular vote or general acceptance. I, for one, do not remember voting. This thinking also denies a very fundamental principle; humans are prone to dogmatically holding a view, regardless of the evidence. The history of science has shown it is not immune to this mental process either. Also, it is my personal observation (and the observation of many others) that the vast majority of active scientists have little knowledge of either evolution or creation. In fact, many are not even aware of the scientific arguments for creation (or the flaws in evolution) and merely accept evolutionary teaching because "everyone else does." This "herd" mentality is very powerful and cannot be underestimated as one reason for the so-called popularity of evolution in the scientific community. Most scientists tend to be evolutionists by default rather than decision.

The prejudice does not stop with rejection of submitted papers. In a tactic reminiscent of Orwell's 1984, some scientists have experienced retribution for failing to follow the "official evolution party line" (you can substitute "big brother" for that phrase). Ben Stein's recent movie *Expelled* highlighted several examples of this retribution, which

included dismissal from professional positions, denial of tenure, and professional censure. While most people would assume (and expect) the scientific community to desire objective dissemination of ideas and information, *Expelled* exposed what many of us already know: the scientific community is actually relatively "closed" to certain ideas and thoughts. There is even a certain level of exclusion to new or unique ideas/models within the specialities of science. Scientists proposing alternatives to currently accepted "theories" of big bang cosmology, quantum mechanics, or membrane biophysics may find themselves ignored "out-of-hand" simply because everybody knows that any alternative model cannot possibly be correct.

All too often certain groups of scientists engage in "paradigm protection." The paradigm becomes more important than the data it is supposed to help explain. It has to be fervently defended against all challengers. I have personally witnessed one or a group of scientists become very emotional in defending their particular paradigm, sometimes against rather overwhelming evidence. Thus, it should hardly be surprising that a concept as "outrageous" as creation science would also find itself pushed aside by those seeking to protect their evolutionary paradigm. In fact, it seems that the more a scientific assertion affects our "worldview," the less objective the scientists discussing that assertion become. All sides are vulnerable to this.

An additional argument frequently offered is that Creation is incompatible with science, because a creator falls outside the realm of science. I would challenge that an appropriate definition of science is simply the process of studying and understanding the world around us. However, such a definition does not exclude the activities of a supernatural creator. For the NAS, AAAS, etc. this is unacceptable. Therefore, science must be defined so that it is totally incompatible with a creator. By doing so, creation

automatically loses any scientific status, thus justifying immediate rejection of creation science manuscripts, creation science in education, etc., etc., etc. “They” revise the definition of science to be a process of understanding the world around us by strictly naturalistic explanations. This does not eliminate the existence of a creating God, they will argue, but the activities of this god are completely outside the realm of science.

However, once the activities of God are moved outside the realm of science, He ultimately also falls outside the realm of human relevance, experience, and meaning. He has no interaction with

human existence, makes no demands, and pays little attention to human affairs. This kind of irrelevant god is “safe” for those who would rather there not be a god (i.e., you can believe in this god if it makes you feel better, but your faith is ultimately indistinguishable from no faith).

Evolutionists will also often insist that because creation claims a supernatural origin of life, it is not testable by scientific methods. Of course it is. The observation that certain events or systems can only be the result of an intelligent agent (such as a computer program) is very scientific. How could it not be? In fact, it is the only scientific position possible. It is derived by the most basic of scientific methods, repeatable observation – i.e., does this happen or not? Life from life happens. Life from nonlife does not happen. There has been no alternative natural origin of life ever shown, despite decades of speculation, supposition, and often preposterous pontification. The only observed origin of life is other life. So, how is it more scientific to say that life originally arose from nonlife (which has never been shown to happen) than to say that life originally arose from other life (which happens all the time)? That this “other life” could be supernatural is consistent with the *law of first cause* (i.e., the ultimate first cause of all things must not require its own cause; an “uncaused cause”).

In *Expelled*, Mr. Stein asked an evolutionist for an explanation of life’s origin. He was told that life may have started on crystals. When he pressed the question about origins further, Mr. Stein was met with a certain disdain that the question had just been answered – life formed on crystals. And this is scientific? Forget the fact that crystals are appealed to as a desperate (and currently unsuccessful) attempt to naturally produce optically pure amino acids. Forget the fact that even the existence of optically pure amino acids is extraordinarily distinct from “life.” No one has demonstrated

that crystals, or clay, or Darwin’s warm little pond, or any conceivable natural condition can form life. Naturalistic explanations of life fail the most basic of scientific tests. They do not happen. Yet, the scientific community continues to promote this unscientific position, while at the same time bashing and ridiculing all “unbelievers” as being unscientific. What we are seeing is a fascinating example of the fear and censorship that Orwell alludes to in his article. In fact, it is an example of what Orwell often alludes to in all of his writings. It is a form of Orwellian “doublethink.”

In scientific circles, critical analysis always sharpens and improves the quality of the work. However, using their control in the scientific community, evolutionists have successfully prevented significant challenges to evolution within the scientific journals. Hiding behind court rulings, evolution has effectively become shielded from the normal challenges and criticism to which other scientific views are constantly exposed. It has gained its own set of civil rights. Is evolution such a weak concept that it needs such protection? Are its proponents so fearful of a great “falling away” if alternative ideas are allowed to be considered? Historically, this has always been a sign of a weak idea, one that cannot compete in a legitimate arena of ideas.

The most effective way to make a clapping sound requires one moving hand to encounter a hand moving in the opposite direction. Without that counter moving hand, there is no sound; there is no clap. This “one hand clapping” ineffectively fans in the air but produces no clapping effect.

Evolutionists are waving one hand through the air, pretending they are clapping for scientific truth and honesty. But in attempting this one-handed clap, they ignore creationist data. They ignore creationist literature. They ignore creationist responses. Evolutionists have written dozens of books in the last few

Can creationists (and even ID proponents) have any alternative but to conclude that their manuscripts are intentionally and systematically being singled out for exclusion? Show me where intentional exclusion is *not* occurring in the scientific literature.

years purporting to answer the creationist challenges and expose the so-called low quality of creationist research. Interestingly, these books pay little actual attention to creationist literature (especially the more recent literature) and merely invent “straw men.” Consequently, when many evolutionists are confronted with the creationist literature (of which they are almost completely ignorant), they often stutter, stammer, deny, and ultimately seek their familiar areas of refuge: It is not science, it is not published in the scientific literature, the scientific community does not recognize it as science. It has become a mantra. But, these responses have nothing to do

with whether the scientific claims and proposals of creationists are actually valid and valuable scientific queries.

If a five-year-old makes a completely true and correct scientific observation, the fact that the observation was made by a five-year-old rather than a member of the NAS does not make the observation less valid. Thus, ignoring the observation is like one-hand clapping and not even realizing there is no clapping sound. How foolish is that?

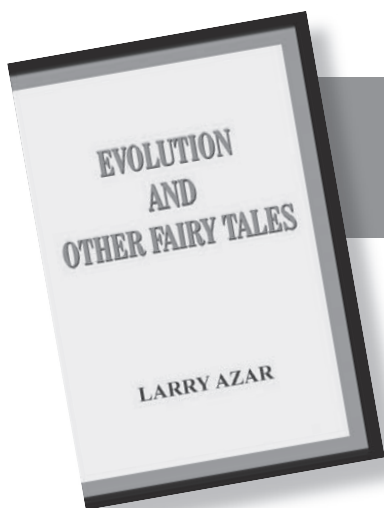
Kevin Anderson, Ph.D.

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Book Review

Evolution and Other Fairy Tales

by Larry Azar

AuthorHouse, Bloomington, IN, 2005, 619 pages, \$14.50.

The late Professor Emeritus Larry Azar, who went to his reward this past summer, received undergraduate and graduate degrees in math, physics, and philosophy from Boston College and a Doctorate in Philosophy from the Pontifical Institute of the University of Toronto. He taught at Fordham, Lehman, Hunter, St. John's, and Iona Universities. Numerous articles

by him have appeared in journals, both national and international.

Evolution and Other Fairy Tales is a thorough philosophical debunking of the theory of Evolution. Larry Azar has done a comprehensive study of the thinking of Charles Darwin and his supporters. What the author uncovers are deeply flawed evolutionary beliefs and

a theory without scientific support.

In this book, Professor Azar highlights Darwin's personal beliefs and some of his fellow evolutionists' beliefs, many of which are contradictory. Also discussed are various facts that reveal the scientific and philosophical problems with the theory of evolution. It is shown that Darwin was heavily influenced by

Thomas Malthus (1766-1834) and his doctrine of the "struggle for existence." Malthus predicted, quite erroneously, that by 1932 the human population would overwhelm the earth. He advocated birth control and praised war, famine, pestilence, and disease as ways of increasing the death rate. Darwin agreed with him on more than one point: "I could show that war has done and is doing much ... for the progress of civilization" (p. 213).

The book also points out that Nazism was based on the idea of a master race. Friedrich Nietzsche (1844-1900) was a famous atheist and is credited with being the link between Darwin and Hitler. Marx was contemporary with Darwin and used the idea of survival of the fittest in his concept of class struggle. Social Darwinism can be directly linked with the extermination of millions of people during the wars and revolutions of the twentieth century.

Two examples of circular reasoning common among evolutionists are highlighted. The first is the concept of the survival of the fittest. Who survives? It is the fittest. Who are the fittest? Those who survive. The other is the use of rocks to date fossils and the use of fossils to date rocks.

One of the more interesting quotes in the book is from Colin Patterson:

"Question is: Can you tell me anything you know about evolution, any one thing that is true? I tried that question on the geology staff at the Field Museum of Natural History, and the only answer I got was silence. I tried it on the members of the Evolutionary Morphology Seminar in the University of Chicago, a very prestigious body of evolutionists, and all I got there was silence for a long time, and eventually one person said, 'I do know one thing – it ought not to be taught in high school'" (p. 464). (Audio and transcript of talk available from Kolbe Center at www.kolbecenter.org.)

The theory of evolution is shown to be nonscientific because it is not testable, not deductive (no direct proof, only inferences) and not observable. Several foundational principles of the theory of evolution that have never been demonstrated are: (1) abiogenesis, (2) single cells combining to form more complex organisms, and (3) multicelled organisms evolving into other organisms.

This book is a gold mine of facts that reveal the scientific and philosophical problems with the theory of evolution. The lack of an index makes it a challenge to dig up these facts, but there are extensive notes and a large bibliography.

Azar himself seems to favor St. Augustine's view of a single act of cre-

ation in which the seeds of all future beings were implanted in the things that were made. In the course of time, these unfolded into all things that proceeded from them.

Azar's widow and friends are in the process of arranging two unpublished books for publication. The first one is called *Squabbles* and uses the words of evolutionists to argue among themselves as if there are no creationists. The second, currently untitled, is a piece that has Moses fired while writing the Pentateuch and the job taken over by a committee to get all of the objectionable creationist content reinterpreted.

Azar never interested himself in the issue of earth age, only to say it is no less incredible that evolution would sustain itself over billions of years than it happened in a few days. He just conceded that it was outside of his field to determine and so went with the prevailing wisdom when making his arguments. He would also say that philosophy is outside the realm of empirical science, but evolutionists are always getting involved in it.

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Toppling the Timescale

Part III: Madness in the Methods

John K. Reed*

Abstract

The chronology of the geologic timescale's stratigraphic units has been defined by a variety of methods. Over the decades many have waxed and waned in popularity, but at present the most important ones are: (1) radiometric dating, (2) astronomical "tuning," (3) magnetostratigraphy, and (4) biostratigraphy. Each of these methods assumes deep time and uniformitarianism rather than demonstrating them. Each also exhibits other specific flaws. These are commonly masked by the "shotgun approach" or the selective use of individual methods. But contrary to popular perception, the "shotgun approach" does not demonstrate the strength of overlapping independent, scientific methods, but instead exhibits a critical weakness—after decades of searching, no single absolute chronometer has been found. The frequent selective shuffling of methods, therefore, demonstrates the failure to attain a real chronology. Thus the absolute timescale (and its stages) rests on quicksand. It is not the concrete empirical history commonly presented; it is instead the unverified historical saga of the worldview of Naturalism, supported more by the faith of its adherents than by factual demonstration.

Introduction

As noted earlier in this series (Reed, 2008a), the geologic timescale is the attempt in the field of earth science to use the rock record as a weapon of the worldview of Naturalism. This often leads to confusion. For example, geologists often talk about two parts of the timescale: (1) the chronostratigraphic order of the rock record, and (2) the geochronologic dates

of each unit. How are these two parts of the timescale validated?

The chronostratigraphic scale is an agreed convention, whereas its calibration to linear time is a matter for discovery or estimation (Gradstein, 2004, p. 3).

This admission is contrary to what most geologists—creationist or unifor-

mitarian—believe. They would see the arrangement of the chronostratigraphic scale as an empirical quest, not an "agreed convention." This wording is crucial, however, for it dovetails precisely with a thesis of this series—that the rocks were arranged according to a deductive template, not by decades of inductive compilation. As we have seen, that template rests on the flawed assumption that rock units represent globally correlative synchronous time units (Reed, 2008b). Furthermore, as we will see, the "discovery" and "estima-

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tion” of the dating of each stage are a far cry from genuine measurement, something required for any truly scientific demonstration.

In other words, we have just unmasked the great weakness of the timescale. *There is no absolute chronometer.* Without exception, all of the dating methods exhibit uncertainty, and they all assume rather than prove deep time.

Before examining the specific flaws, several general problems are worth noting. First, the multiplicity of methods is often presented as a strength of the timescale—multiple independent, overlapping lines of evidence. That appraisal is overly optimistic. Instead, the need to bounce back and forth from one method to another reveals the fundamental lack of a consistent “clock” against which the rocks can be calibrated. A factual summary of history should include a reliable “clock.” But the path across the past two centuries is littered with a steady stream of discarded methods; each vigorously proclaimed in their day as scientific gospel. Yet over time, flaws and shortcomings were uncovered in each “infallible” method. Those repeated failures should have led geologists to question the timescale; instead, new methods were churned out to replace the old while their confidence in uniformitarian history and Naturalism never wavered. Critics of the timescale thus found their efforts to be much like punching Jell-O.

Over time this multiplicity of methods created another problem. Different parts of the timescale are now “validated” by different methods (Figure 1). But how can a unified history be derived from this patchwork? If deep time is so obvious, why is there not a single chronometer that proves it? This leads to another problem—one that most geologists downplay, especially with the public.

However, the geologic record is discontinuous, and these stratotype-

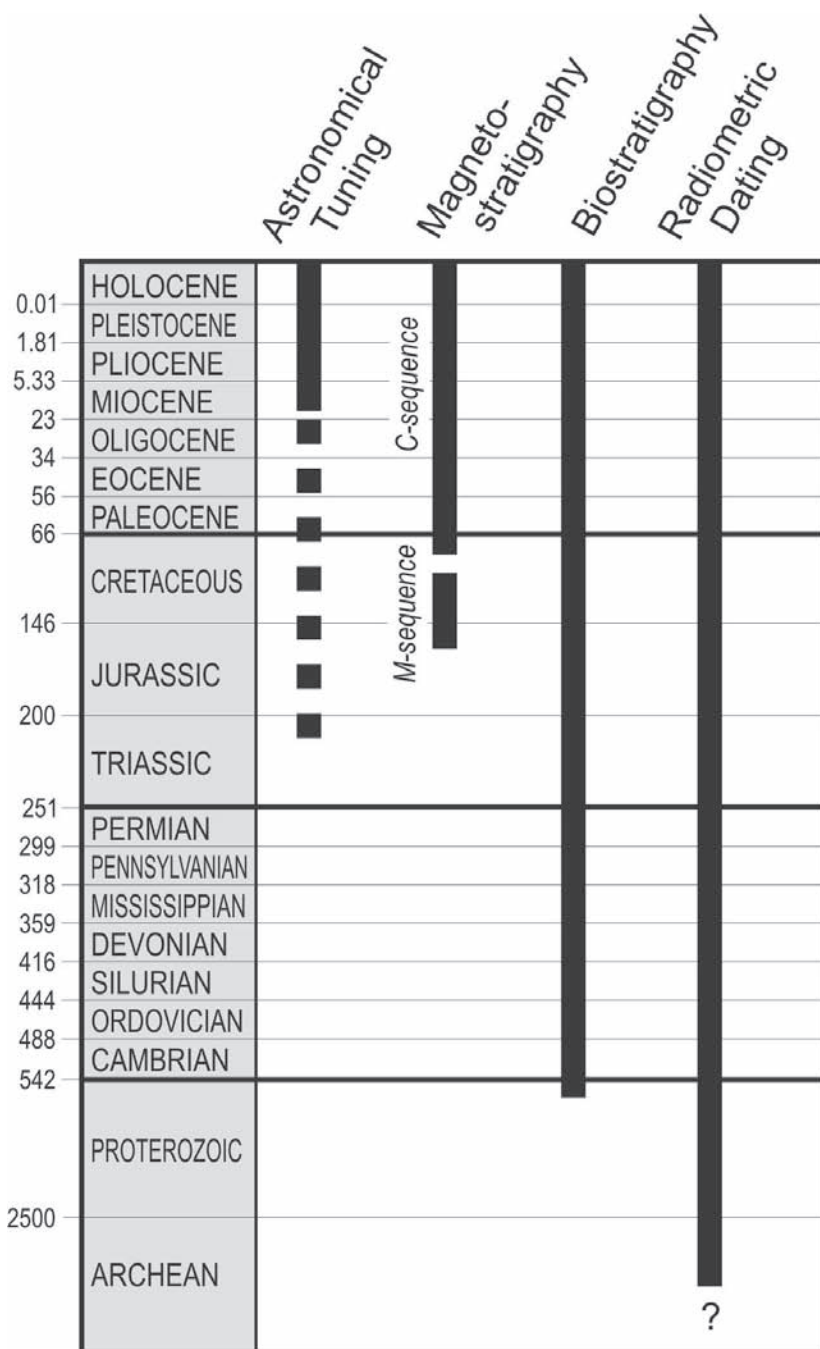


Figure 1. The current geologic timescale uses a variety of methods to validate its history. Radiometric dating and astronomical tuning are the only two possible methods that can provide absolute dates. However, the latter extends only a short distance back into “deep time.” Radiometric dating fails on several counts (see text). Magnetostratigraphy only offers partial coverage and must be calibrated to radiometric dates and hypothetical sea floor spreading rates. Biostratigraphy, once the “queen of the methods,” has suffered many setbacks in conjunction with the falling fortunes of evolution.

based chronostratigraphic units are an imperfect record of the continuum of geologic time (Gradstein et al., 2004b, p. 20).

When geologists admit this discontinuity, they continue quickly on as if it were of little import. But it is a critical admission, *given the constraints of their worldview*. For the pure empiricist, the absence of tangible evidence is a huge problem. Since uniformitarian natural history rests on the empirical description of the past, *any* empirical discontinuity in the rock record presents a challenge. And it is not simply a few missing pieces of the puzzle; the vast majority of rocks ever hypothetically deposited in the uniformitarian scenario are missing. A careful reading of any local stratigraphic description will note large chunks of missing time. Even worse, a detailed analysis will show that the actual time of deposition for a given formation is much less than the total time for its stage, even if the accompanying stratigraphic chart colors in the entire stage with that rock unit! This “scale masking” (Reed, 2000) occurs because the scale on any stratigraphic chart is so large that a single line thickness can often equal thousands of years.

If rocks do not form layers that measure isochronous discrete time periods, and if they cannot be correlated globally, then the spotty record cannot be pieced together unless the assemblers know the result in advance, much like having the picture on the puzzle box to guide your efforts. Since the rocks are not complete in and of themselves, a template is needed. Creationists use biblical history as that template and can thus accommodate discontinuities in the rock record. But adherents of the naturalist worldview do not have that luxury since they claim a purely empirical basis for their knowledge of history. For all they know, little green men could have landed on Earth and influenced the course of evolution—as long as it happened during a “hiatus” in the rocks. An

incomplete rock record is an incomplete history, and an incomplete history is an uncertain history (though you would never guess that from the public confidence expressed by stratigraphers).

In addition to these conceptual problems, stratigraphers face many others with specific geochronologic methods. We will first examine those currently popular and then look at others—once at the forefront of “science” but since relegated to semiretirement. The former are like the starting rotation on a baseball team. Those not currently in vogue are kept in the “bullpen” in case one of the “starters” gets into trouble.

The “Starting Rotation”

At present, there are four primary methods that are used to validate different parts of the timescale. From the basement up, these include radiometric dating for the Precambrian, biostratigraphy for the Paleozoic and parts of the Mesozoic, magnetostratigraphy for parts of the Mesozoic and Cenozoic, and “tuning” to astronomical cycles for most of the Cenozoic.

Aspects of the GTS89 compilation began a trend in which different portions of the geologic time scale were calibrated by different methods. The Paleozoic and early Mesozoic portions continued to be dominated by refinement of integrating biostratigraphy with radiometric tie points, whereas the late Mesozoic and Cenozoic also utilized oceanic magnetic anomaly patterns and astronomical tuning (Gradstein, 2004, p. 10).

In addition, there are secondary methods, including calibration by various isotopic ratios. This will be discussed after the “starting four.”

Radiometric Dating

The “ace” of the staff is radiometric dating because it provides the only theoretical way to directly obtain absolute dates

for virtually all of the rock record. Since the early twentieth century, geologists have relied on radiometric methods to specify and validate the deep time demanded by evolution. Though recent efforts have been made to correlate strata to dates derived from astronomical cycles, radiometric dates have provided the bulk of the absolute dates that have calibrated the timescale.

The chronometric calibration of stratigraphic boundaries underpins the geologic time scale.... In particular, there is now a heavy reliance on results from the analytically precise $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb methods at the expense of K-Ar and Rb-Sr dates, which were the mainstay of older time scales (Villeneuve, 2004, p. 87).

When first introduced, radiometric methods seemed to provide definitive proof of deep time and were used to silence young-earth critics, particularly Lord Kelvin. However, in-depth creationist critiques of radiometric methods have shown significant flaws in individual methods as well as in the assumptions underlying the entire system (Vardiman et al., 2000; 2005; Woodmorappe, 1999). In particular, Woodmorappe (1999) showed a systematic historical cycling from one radiometric method to another as each new process revealed its flaws (as admitted in the above quote), and Austin (2005) and Snelling (2005) demonstrated discordance between various isotopic methods (including isochron methods) by dating the same rocks by a variety of methods. Given the repeated admitted shortcomings of the older methods and the demonstrated discordance of the newer ones, it appears that the rock-solid chronology of radioisotopes has turned into quicksand. A summary of the most common radiometric methods and their many shortcomings is presented in Snelling (in press).

Fundamentally, isotopic dates cannot confirm the stages of the timescale because uncertainty in these methods

precludes a certain chronology. This brings the argument back to the original problem: deep time is required by evolution, but since that is the issue in question, evolution itself cannot logically demonstrate deep time. If radiometric dating is uncertain, then geologists continue to argue in a circle. This is because the primary argument about radiometric dating is not whether it is generally correct or generally incorrect but whether or not it is *the reliable chronometer*—the magic hammer that can set the golden spikes of time. A method that is not absolute cannot provide absolute dates. If it can be wrong some of the time, then it can be wrong at any given time, and therefore any given date cannot possess the certainty generally assumed by stratigraphers. For example, note how the argument that current methods are accurate reveals inaccuracies in other methods that once enjoyed equal confidence.

Few other methods can attain the accuracy or precision of the $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb TIMS methods and, for this reason, key chronostratigraphic calibrations now depend almost exclusively upon them, with minor infill from K-Ar. Rubidium-Strontium (Rb-Sr) decay was once widespread in its use for geochronological purposes, but recognition of the mobility of both Rb and Sr in the presence of aqueous fluids or thermal disturbances has led to the method falling into disfavor as a precision chronometric tool.... Samarium-Neodymium (Sm-Nd) decay is of limited applicability because of relatively low distribution coefficients between the parent and daughter atoms during crustal processes, resulting in relatively little control on generation of isochrons (Villeneuve, 2004, p. 94).

As Snelling (in press) notes,

There are many problems with each of the radiometric dating methods. These are admitted by the conven-

tional geology community in their own papers and textbooks, yet they fail to draw the commonsense inference that these methods are highly questionable at best. In spite of these known problems, the millions of years demanded by the geologic timescale and evolution are accepted and research continues with these flawed methods because they are consistent with the evolutionary model of earth history. Though reluctantly admitted, the problems are usually ignored because radiometric methods are thought to be at least generally correct, in spite of the fact that these anomalies defy and disprove the very assumptions foundational to the methods.... All these considerations taken together emphatically show that the radiometric dating methods are fatally flawed and cannot yield the valid absolute ages claimed by those who require the millions of years to prop up their belief in long evolutionary ages of earth history.

Thus, while radiometric dating remains the mainstay of the timescale, it does so because the alternative is to admit what creationists have been saying for decades—that the age of the earth has not been demonstrated to be measured in billions of years and that the historical record of the Bible is back on the table.

Biostratigraphy

Biostratigraphy is the use of index fossils to assign ages to the rocks that contain them. As has been noted by many creationists, the argument is circular because the deep time of evolution is a presupposition of the method. Yet, it remains the standard for much of the fossil-bearing strata.

The larger part of the Phanerozoic time scale...relies on a construction where stages are first scaled “geologically” with biostratigraphic compositing techniques, and then

stretched in linear time using key radiometric dates (Gradstein et al., 2004a, p. 49).

As an aside, note that the use of “key” radiometric dates tacitly admits that some are better than others. How can we tell one from the other? But the quote is more interesting in what it says about biostratigraphy. Time periods or stages are “scaled geologically” or assembled in their “proper order” using index fossils. This can happen only if the truth of evolution is known in advance and if its progression is adequately preserved in the fossil record. Neither has been demonstrated. Furthermore, if the timescale has to be stretched in linear time with radiometric dates, does not that imply that the rock record itself does not give the appearance of age determined by radiometric methods—even with the assumption of evolution?

In addition to the circularity problem, biostratigraphy faces other issues.

- Fossilization assumes in situ, low-energy paleoenvironments. Any high-energy catastrophic transport of fossils out of their “home” environment invalidates the scheme.
- Since fossils do not show evolutionary transitions, the dates are purely conceptual. This is demonstrated by comparing the evolutionary “dates” from the nineteenth century with those of the twentieth century.
- Ignorance of the complete fossil record demands empirical uncertainty.
- Living fossils and changing ranges of index fossils highlight that uncertainty.
- The predominance of marine invertebrates as index fossils arbitrarily biases sampling (Mortensen, 2006).

These difficulties have been recognized (or at least admitted) in recent years, resulting in the changes to deriving the timescale noted in this series.

Note the admission of failure in the following quote.

Even so, the practice continued of treating strata divisions largely as biostratigraphic units, and even today it is an article of faith for many Earth scientists that divisions of the developing international stratigraphic scale are defined by the fossil content of the rocks. To follow this through, however, leads to difficulties: boundaries may change with new fossil discoveries; boundaries defined by particular fossils will tend to be diachronous; there will be disagreement as to which taxa shall be definitive (Gradstein, 2004, p. 21).

This is an astounding admission, echoing creationist criticisms. For nearly 200 years, naturalists have asserted that evolutionary history is preserved in the rocks and have thrown that rock record into the teeth of Christianity. Yet now we learn that the biostratigraphic interpretation of the rock record is perhaps not so clear after all. This leaves naturalists with a profound dilemma. Evolution is the only logical continuous universal clock available to track “deep time.” Without it, the whole house of cards collapses. If we begin with a skeptical eye toward evolution, the problems are much worse. Stratigraphy rests on the hope of a legible fossil progression in the rocks; if that does not work, then the whole edifice is vulnerable.

Correlation to Astronomical Cycles

One of the newer methods involves correlating chemical trends in cyclic sediments (e.g., variations between interbedded carbonate and marl) to the “clock” derived from the orbital oscillations of our solar system. For many years, this method, loosely known as the Milankovitch theory, was the domain of glaciologists. More recently, geologists have begun to believe that resulting climate changes are sufficiently strong to be reflected in sedimentary cycles.

Over the past century, paleoclimatological research has led to wide acceptance that quasi-periodic oscillations in the Sun-Earth position have induced significant variations in the Earth’s past climate. These orbitally forced variations influenced climate-sensitive sedimentation, and thereby came to be fossilized in the Earth’s cyclic stratigraphic record (Hinnov, 2004, p. 55).

All such oscillations boil down to variations in solar radiation (the insolation signal) reaching Earth due to differential gravitational effects exerted by celestial bodies. Oscillations include eccentricity (the variation in the elliptical shape of Earth’s orbit) with cycles of 95, 125, and 400 Kyr (thousand years); obliquity (the tilt of Earth’s axis of spin with respect to the ecliptic) with a cycle of 41 Kyr; and precession (the wobble in Earth’s spin) with cycles of 19 and 23 Kyr. The Milankovitch theory states that changes in these parameters cause corresponding changes in sunlight reaching Earth and thus long-term climate change (c.f. Oard, 1984). Although initially used to explain the ice ages, the theory has been more widely applied in recent years to sedimentary cycles (Oard, 1997), especially those from pelagic environments.

Cycle stratigraphy has calibrated the time scales for most of the Neogene Period (i.e. for the past 23 million years), and for portions of the Paleogene Period (from 65 to 23 Ma) and Mesozoic Era (from 251 to 65 Ma) (Gradstein, 2004, p. 4).

This tuning of sedimentation to astronomical cycles requires at least three important assumptions. These are: (1) cause and effect between oscillations and sedimentation to the extent that this “signal” overrides terrestrial influences, (2) cyclicity and continuity in sedimentation driven predominantly by climate, and (3) uniformity of rates and preservation that enable the “signature” to be manifested. Stratigraphers assume

that sediments present a linear “signal” through time that can be differentiated from any nonlinear “noise.” But this assumption itself presents problems, and the preferences of the researchers drive conclusions.

Despite the view that non-linear approaches might explain more of the data than the linear methods, the latter are currently best understood mathematically and are *the most frequently used* (Weedon, 2003, p. 2, emphasis added).

In short, the astronomical data coupled with the assumption of deep time result in a theoretical plot of solar radiation versus time. Geologists then fit paleoclimatic information (e.g., glacial and interglacial periods) to this curve, but move beyond that into fitting chemical variation in cyclic sediments presumed to have been deposited over millions of years.

True orbital time calibration is possible only for cycle stratigraphy that can be connected to the “canonical” orbital variations, i.e., those quantitatively predicted by orbital theory. In GTS2004, this involves cycle stratigraphy back to the Miocene-Oligocene boundary only (0-23.0 Ma). Calibration of a sequence of cyclic strata begins with the assumption of a target orbital curve. This may take the form of an orbitally forced insolation signal, which most likely affected climate and was subsequently recorded by sedimentation..., or it can be as simple as the sum of the standardized orbital parameters.... This initial assumption, however, introduces a basic source of error, because the true nature of the orbital forcing of the sediment is not known exactly (Hinnov, 2004, p. 61).

The attraction of the method is that it potentially provides a timescale to reinforce that provided by radiometric dating. But the method is not without its problems. Primary among them are:

- It cannot be applied to “old” sediments, and so cannot calibrate the entire timescale.

It should be noted that cycle stratigraphy much older than ~20 Ma may never successfully be correlated directly to the orbital cycles but only indirectly through comparison of average signal characteristics between data and orbital theory (Hinnov, 2004, p. 60).

- It is difficult to apply to geographically diverse areas.

All Cenozoic standard stages are originally based on European stratotypes, with the Neogene Mediterranean ones more difficult to correlate worldwide as a function of increasing provincialism and diachronism in faunal and floral events in the face of high latitude climatic cooling (Gradstein, 2004, p. 16).

- It presupposes uniformitarianism.

Floating orbital time scales (i.e. time scales that are disconnected from canonical orbital variations) are based upon the assumption that frequency components observed in cycle stratigraphy can be related to one or several frequencies predicted by orbital theory. This requires an additional, provisional, assumption that planetary motions were stable back to the geological time represented by the data, and that current models of tidal dissipation and dynamical ellipticity which predict progressively shorter orbital periodicities back through time...are accurate. This assumption, however, remains largely untested for times prior to the Oligocene (Hinnov, 2004, p. 62).

Also, as noted by Oard (1984; 1985) and Vardiman (1996), short-term terrestrial influences are likely to swamp the astronomical signal. For example, unpredictable volcanic eruptions and sunspot activity have been correlated to climatic changes, and those signals have a higher “frequency” and “amplitude”

relative to any orbital parameters. Like varves or ice layers, geologists simplistically assume that the target sediments were deposited slowly, uniformly, and in response to regular climatic variables. Remove those assumptions and the whole theory crumbles, as has been shown for both ice layers (Oard, 2005) and varves (Oard, in press).

Also, any rapid or catastrophic style of sedimentation would render this style of dating meaningless. Sedimentation is influenced by source, by tectonics, and by preservation potential. All of these must be ideally uniform to generate a legible astronomical signature in the sediments. This would be difficult, even in an old-earth setting. For example, diagenesis could easily alter carbonate sequences enough to mask the signal (Westphal et al., 2004). It is also not clear how this very slow climatic signal can be realistically applied to sediments; in other words, does this regular astronomical cyclicity provide a sufficiently strong signal to overcome all others? A large submarine slump would generate turbidites that hypothetically could show a regular cycle of interbedded lithologies. Yet deposition would happen instantaneously. What would a plot of the various chemical ratios up through such a deposit show?

In any forensic study, subjectivity and uncertainty cannot be eliminated. Weedon (2003) noted,

Hilgen...and Shackleton...independently derived orbital cycle chronologies based on matching sedimentary cycles and oxygen isotope curves to the calculated history of insolation changes.... The results were at odds with the widely accepted radiometric ages that had been obtained using potassium-argon dating. Subsequently, improved radiometric dating and studies of sea-floor spreading rates confirmed the validity and utility of the so-called astronomical time scale approach. (p. 3)

Note that the basic data were initially in conflict—a conflict resolved in favor of the preferred “new” approach and then “validated” once the answer was “known.” Although Weedon presented this example to illustrate the strength of astronomical tuning, it really demonstrates the arbitrary use of radiometric methods and the subjectivity of the researchers.

Finally, a history that includes the Flood cannot be compared to the strict uniformitarianism assumed by cyclostratigraphers. For example, the early and late stages of the Flood were marked by dramatic volcanism. The local increases of ions and temperature in seawater would have dramatically overridden any potential insolation changes and would in fact have been responsible for variations in solar radiation at Earth’s surface far in excess of any orbital variation. Similarly, meteoric bombardment would have affected the insolation signal much more dramatically than any orbital variation. Ultimately, these methods presuppose the very thing they purport to prove.

Magnetostratigraphy

The introduction of plate tectonic theory in the 1960s was closely tied to burgeoning studies of the magnetic signatures of various rocks, particularly the alternating normal and reversed “stripes” parallel to the midocean ridges. Many historians of science date the plate tectonic revolution to the famous paper of Vine and Matthews (1963), which described the “symmetrical” magnetic stripes on either side of the Mid-Atlantic Ridge. Dating of the component rocks provided a rate for plate spreading that was extrapolated into the magnetic time scale.

Oceanic magnetic anomalies are calibrated with spreading models to produce a powerful correlation tool for sediments deposited during the past 160 million years. These calibrated C-sequence [Late Cretaceous–Neogene] and M-sequence

[Late Jurassic–Early Cretaceous] polarity time scales enable assignment of ages to stage boundaries and to biostratigraphic and other stratigraphic events through much of that interval (Gradstein, 2004, pp. 4-5, brackets added).

Note that this assumes plate tectonic theory and measurable spreading rates. But if the rocks can be dated well enough to supply those rates, then why is there a need for magnetostratigraphy? As with the other methods, none are really independent, but an illusion of strength is supplied by the inference that they are all mutually supporting.

The patterns of marine magnetic anomalies... have been calibrated by magnetostratigraphic studies to biostratigraphy, cyclostratigraphy, and a few radiometrically dated levels (Ogg and Smith, 2004, p. 63).

There are a number of problems with magnetostratigraphy, and many have been discussed by creationists (e.g., Oard, 1985). First, although there is good evidence for the historic reversal of Earth's magnetic field, the process of magnetic reversal is unexplained and the mechanism unsubstantiated. If we do not know how the magnetic field changes through time, the presence of ancient signatures remains somewhat of a mystery and we cannot accurately decrypt their relationship to history. The origin of the magnetic fluctuations that actually cause the seafloor "stripes" is also unknown. Barnes (1971; 1973) showed many years ago that the observed decay of Earth's magnetic field fits a young-earth framework and that the evolutionary dynamo theories could not explain the data. This work was later reinforced by Humphreys (1986; 1988), who noted that rapid reversals documented in the rock record support a catastrophic interpretation of magnetic polarity changes rather than the uniformitarian model. These creationist critiques pose large problems for uniformitarian magnetostratigraphy.

However the most significant weakness of magnetostratigraphy is its inherent inability to provide an unambiguous chronometer. That is because the magnetic signature (granting its accuracy) is either normal or reversed. It is like a simple switch; alternating between "on" and "off." Since this happens repeatedly over time, we cannot possibly know what interval of history is represented by any given "on" or "off" signal unless we already know the approximate age of the rock.

Furthermore, magnetostratigraphy can be misleading in this respect because the assembled timescale of magnetic chrons shows a distinct pattern of thick and thin intervals of normal and reversed segments. It appears at first glance that it should be easy to correlate the overall pattern, similar to correlating well logs. However, that pattern is measured in the domain of *time*, and time must be inferred or imputed into the rock record. A thick section of rock might represent a thin polarity chron, while a thin section of rock might represent a thick chron. Until the rock is independently dated, no magnetic verification or "fine tuning" of the stratigraphy can occur. Thus, even though clear correlation appears possible at first glance, it is not.

It is essential to have some biostratigraphic constraints on the polarity zone pattern resolved from any given section in order to propose a non-ambiguous correlation to the reference geomagnetic polarity time scale (Ogg and Smith, 2004, p. 64).

In other words, rocks are dated by fossil succession and "verified" by magnetic measurement. Or, rocks are dated by isotopic methods and then calibrated to a magnetic time scale by various manipulations.

A composite C-sequence magnetic anomaly pattern for the latest Cretaceous and Cenozoic was assembled by Cande and Kent (1992a, 1995) from a composite of South Atlantic

profiles with additional resolution from selected Pacific surveys. An absolute age model for this synthetic "CK92" magnetic anomaly pattern was calculated by applying a cubic-spline fit to selected radiometric age controls.... Berggren et al. (1995a) calibrated a vast array of biostratigraphic and chronostratigraphic events to a revision ("CK95") of this geomagnetic polarity time scale to construct a detailed Cenozoic chronostratigraphic time scale (Ogg and Smith, 2004, p. 73).

Like cyclostratigraphy, magnetostratigraphy often boils down to pattern matching of derived curves—a process that can be quite subjective. There are also inherent problems, such as secondary magnetization.

In practice, secondary magnetizations are acquired by sediments or lavas upon compaction, lithification, diagenesis, long-term exposure to other magnetic field directions, and other processes. Therefore, various methods of demagnetization are required to separate the later secondary components from the primary magnetization directions, if such an unambiguous result is possible (Ogg and Smith, 2004, p. 64).

What about the magnetic timescale of the ocean floors? Is it not calibrated by the alternating stripes moving away from the present-day spreading center at the mid-ocean ridges? First, the idealized alternating normal and reversed stripes shown in cartoon figures are much less ideal in the real world. In many places on the ocean floor, the lateral arrangement of polarities is quite ambiguous. A quantitative assessment of anomalies along the Reykjanes Ridge, the location touted as the ideal example of marine magnetic anomaly patterns, showed a better correlation coefficient between magnetic intensity and topography than along strike in a single anomaly, while both of these had higher correlation

coefficients than “same-age” anomalies across the ridge (Agocs et al., 1992). Polarity “stripes” have been found to vary vertically with depth as well as horizontally. Belousov (1980) correlated marine anomalies dated at 8 Ma to much “younger” volcanic rocks on Iceland. Furthermore, where “stripes” do appear near mid-ocean ridges, their thickness variations are at odds with predicted spreading rates (Pratt, 2000).

Isotope Stratigraphy

In addition to the “big four” methods discussed above, geologists also rely on the secondary method of calibrating age dates by isotopic ratios, primarily those of strontium. Just as unstable isotopes are used to date rocks via decay chains, stable isotopes are used to do the same, based on the assumption that isotopic ratios vary predictably through time.

The $^{87}\text{Sr}/^{86}\text{Sr}$ value of Sr dissolved in the world’s oceans has varied through time, which allows one to date and correlate sediments (McArthur and Howarth, 2004, p. 96).

The problem with this type of method is that once again there is no fixed variation through time. There is

just a curve that varies up and down. Thus, a single value would be repeated many times and cannot be time determinative. That means that a particular isotopic ratio cannot provide a definitive age, since many different ages could be derived from an isotope ratio (Figure 2). The method also makes assumptions about the past chemistry of the ocean that require a strict uniformitarian approach.

The method works only for marine minerals. Practitioners assume that the oceans are homogeneous with respect to $^{87}\text{Sr}/^{86}\text{Sr}$ and always were so (McArthur and Howarth, 2004, p. 98).

Like most other methods, the “age” must be known in advance because the uncertainties are numerous.

The calibration curve...is based on measurement of $^{87}\text{Sr}/^{86}\text{Sr}$ in samples dated by biostratigraphy, magnetostratigraphy, and astrochronology (mostly the first two). The difficulty of assigning numerical ages to sedimentary rocks by the first two methods is well known. Users of the calibration curve, and the equivalent look-up tables derived from it that

enable rapid conversion of $^{87}\text{Sr}/^{86}\text{Sr}$ to age and vice versa...must recognize that the original numerical ages on which the curve is based may include uncertainties derived from interpolation, extrapolation, and indirect stratigraphic correlations and may suffer from problems of boundary recognition (both bio- and magnetostratigraphic), diachroneity, and assumptions concerning sedimentation rate, all of which contribute uncertainly [sic] to the age models used to generate the calibration line. Furthermore, age models are ultimately based (mostly) on radiometric dates and are as accurate as those dates. Interpolation of ages between tie points, however, may be more precise, although necessarily systematically inaccurate (McArthur and Howarth, 2004, p. 100).

The “Bullpen”

In spite of an impressive array of new methods, the structure of the timescale has remained surprisingly unchanged for more than a century. Of course there has been refinement of detail,

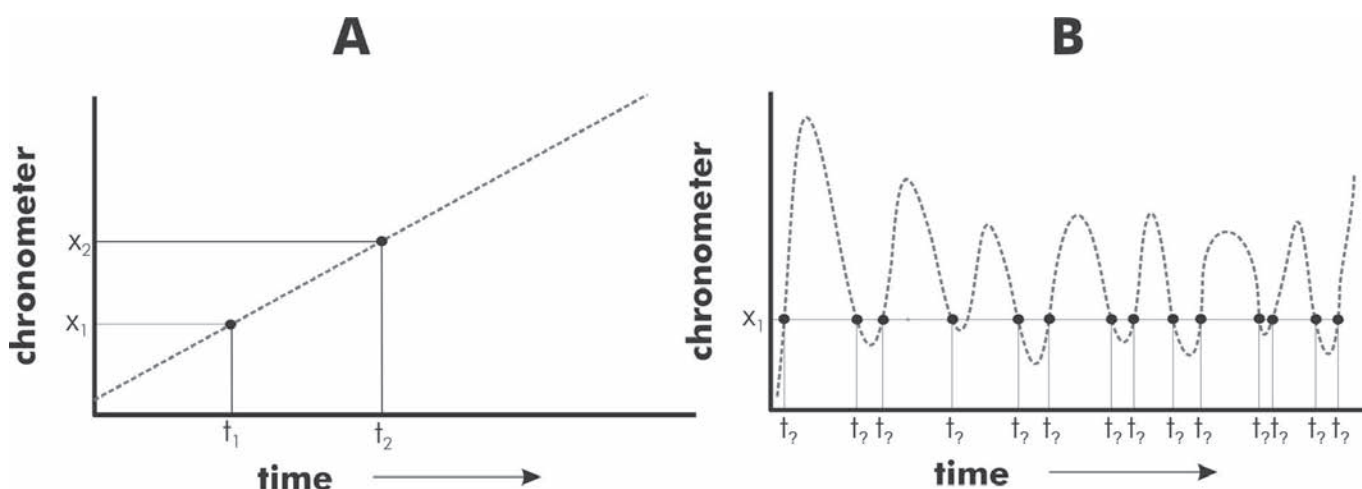


Figure 2. An absolute chronometer (A) must provide a unique value for each unique point in time. A repeating function or curve through time (B) cannot be an absolute chronometer because a single value on the “clock” can correspond to multiple points in time.

new names introduced, subdivision of the sections, and the multiplication of supposedly quantitative timescales. But it seems incredible that the basic structure has not been altered by field research. That can mean one of two things: (1) the rock record is so transparent that early stratigraphic work in England and Western Europe captured its essence almost exactly, or (2) the timescale is a historical template resting on a philosophical worldview rather than empirical science, and data are made to fit the template regardless of methodology.

One of the reasons to suspect the latter is that geologists' confidence in the timescale has never wavered, even when methods that supposedly guaranteed its validity have proven ineffective and have been displaced. Despite acknowledged problems with the various methods, the timescale itself is never in doubt. Although most of the older methods (in their own day thought irrefutable) have been shown to contain flaws, some are still dusted off and used as needed when the current methods are not applicable. These older methods include everything from the assumption that each stratigraphic stage occupied a similar period of time to the assumption of constant plate tectonic spreading rates through time. This "bullpen" of techniques is worth examining, both for their present (although limited) application and for their historical interest. Gradstein (2004, see his figure 1.3) lists a number of these methods. These can be classified by their logical shortcomings.

First are *the assumption of a maximum thickness of sediments per time period* and *the assumption that the temporal duration of a zone is proportional to its thickness*. Both are highly doubtful because they (1) assume a complete sedimentary record, (2) assume a knowledge of sedimentation rates, (3) assume a uniform rate for a given period, and (4) do not discriminate by sedimentary or tectonic environment.

Second are *the assumptions of equal duration of stages* and *the equal duration of zone to scale stages*. Both are purely arbitrary assumptions rooted in extreme uniformitarianism.

Third is *the assumption of constant spreading rates* of ocean floor sections of plates. This of course assumes both the reality of plate tectonic theory and a strict uniformitarianism.

When used today, many of these assumptions are masked by mathematical and statistical methods. Geomathematical and statistical interpolations depend on the quality of the data being assessed, its relevance to the particular method, and uniformitarianism. The same applies to attempts to use a best-fit line of age dates to assign stratigraphic boundaries.

The only valid method used since the development of stratigraphy is what is called "stratigraphic reasoning."

Radiometric age dating, stratigraphic reasoning, and biostratigraphic/geomagnetic calibrations are three corner stones of time scale building. Stratigraphic reasoning, *though fuzzy*, evaluates the complex web of correlations around stage boundaries or other key levels, and is paramount in the science of stratigraphy (Gradstein, 2004, p. 7, emphasis added).

Stratigraphic reasoning includes assessing the relative position of formations, crosscutting relationships, and superposition. Despite the uncertainties in this approach, it remains the best possible approach and the one most commonly applied by geologists pursuing economic objectives. Other than being restricted to individual basins, its weakness lies in its (inherent) uncertainty in establishing an absolute timescale. Then there is the irrelevance of evolution, uniformitarianism, and deep time to correlation. In other words, stratigraphic reasoning is what field geologists use to correlate and map rock units. Because the establishment and defense of a particular historical template

is not the primary focus, the method has fewer pitfalls because it is more closely tied to empirical stratigraphy (Reed et al., 2006).

Discussion

Given Gradstein's (2004) assertion that "the chronostratigraphic scale is an agreed convention, whereas its calibration to linear time is a matter for discovery or estimation," (p. 3) how have stratigraphers done in constructing an absolute timescale?

It seems that recent years have shown a weakening in that construct, rather than improvement. Despite all the theoretical stratigraphic methods, the vast majority of stratigraphy has utilized the tried and true method of evolutionary fossil succession. Radiometric dates tie the framework to "real history," even though many of the methods deriving these dates have subsequently been shown to be in error. But the convenience of having a real timescale has overridden the strict empiricism one usually associates with science.

First, it is clear that there is no single absolute chronometer. In fact, there is only one possible candidate: radiometric dating. Biostratigraphy inherently cannot provide absolute dating and magnetostratigraphy and stable isotopic methods must be calibrated by radiometric dates. Most people quite logically conclude that radiometric dating provides the gold standard for dating, but that misapprehension is revealed by the simple logic of any contradiction between it and other methods. The mere necessity for the other methods shows what professional stratigraphers think about isotopic techniques. Whenever a paleontologist strikes down an isotopic date because it does not "fit" the fossil data, he is demonstrating the failure of radiometric dating as an absolute standard.

If none of the methods can individually supply an absolute chronometer,

then can various combinations of methods fill the gap? That is the common wisdom of the day. However, there are at least two logical requirements for such an arrangement to be valid (much less true). The first is the independence of the component methods, and the second would be a set of realistic assumptions underlying each part.

The combination of any of these methods fails the first test immediately. As noted already, biostratigraphy, stable isotope stratigraphy, and magnetostratigraphy cannot provide absolute dates without the calibration by radiometric dating. Furthermore, only radiometric dating is consistently applied to the Precambrian, which constitutes nearly 90% of the historical record. So the “combined methods” approach is not even attempted for the first 4,000,000,000 years of Earth’s supposed history. Biostratigraphy is extended back into the late Precambrian but cannot provide absolute dates. Magnetic reversals must be calibrated by radiometric dates, and are not considered reliable beyond the Mesozoic. Astronomical tuning has even a shorter zone of application. Furthermore, biostratigraphy (which cannot do absolute dating) is often used to overturn otherwise “reliable” results from methods that can.

None these methods meet the second criterion either. Rather than demonstrating deep time, all of the methods underlying the timescale assume it to be true. Creationists have demonstrated numerous flaws in the concept of motes-to-man evolution, yet evolutionary fossil succession remains a mainstay of the timescale. Over time, geologists have quietly abandoned a number of radiometric methods as obvious problems came to light (Woodmorappe, 1999). Furthermore, creationists have shown similar problems and profound inconsistencies with “modern” methods of isotopic dating. They have demonstrated plausible alternatives to the old-age interpretations of isotopic ratios in rocks

(Vardiman et al., 2000; 2005). The currently accepted interpretations of magnetic signatures depend on: (1) a very unlikely uniformitarian dynamo theory of Earth’s core, (2) the indemonstrable historical fact of plate tectonic motions, and (3) the necessity of knowing the approximate age of the rock to calibrate the magnetic normal or reversed signature. Like stable isotopic ratios, a repeating pattern of results through the rock record cannot provide an absolute date when the same point occurs at repeated intervals through time.

So what is the basis of assigning a historical date to a particular rock, unconformity, or tectonic feature? At this point we must remember that if no historical reality can be demonstrated for the numerous stage boundaries within the timescale, then the historical reality of the stages themselves is quite suspect and may very well be a product of human imagination rather than human science. How do modern stratigraphers handle these problems? For the most part, they cannot abandon the tried and true tradition of the past two centuries. They assume the truth of the timescale a priori and thus assume that the methods supporting it will provide real historical results despite their clear flaws.

Conclusion

The displacement of biblical history by natural science relied on the perception that scientific methods provided greater historical certainty than the long-accepted historical accounts of the Bible. To that end, the methods undergirding the geological timescale have always been sold to the public as hard science, in contrast to “blind faith” in the biblical accounts. Yet it seems that the hard science is not so firm after all. The current stable of “scientific” methods is riddled by uncertainty, and a very large element of faith is needed to believe that they constitute a valid and verifi-

able chronometer of Earth’s supposed 4.5 billion-year past. In reality, there is no “silver bullet,” no single absolute clock that has measured uniformitarian history.

However, the timescale is presented with all the confidence of last year’s calendar. All the flawed methods are collected and presented in a “shotgun approach,” as if the combination of flawed individual methods could somehow magically combine to form an unflawed chronometer. This is no different than taking a broken crystal, a bent casing, and a cracked mainspring; and assembling them and presenting the final product as a Rolex!

The motivation for this erroneous approach lies in the desperation that secularists are beginning to feel. Weaknesses in evolutionary theory have left uniformitarian deep time as the most stalwart fortress against a resurging interest in biblical history. The supposed “scientific” timescale has fooled countless people for two centuries, including (unfortunately) many Christians. Therefore, if the timescale is a house of cards built on quicksand, the arguments of Enlightenment secularism against the reality of biblical history are in reality no more than chaff ready to be scattered by the first strong gust of reason. Thus, the fundamental weaknesses of the contemporary timescale provide a powerful argument that Enlightenment geology has sold us an erroneous version of the past. It is high time to turn abandon this flawed approach and return to the reliable history of the Bible.

But if these weaknesses are so obvious, why are they not more readily admitted by geologists? As the next installment in this series will show, the problems with the timescale *are* beginning to be appreciated—at least by the high priests of stratigraphy. As a result, they are taking radical and dramatic steps to insulate the timescale from any future criticism by removing it completely from the empirical realm. The so-called “empirical”

history is becoming nothing more than a fiat decree of secular dogmatists, as will be described in Part IV of this series.

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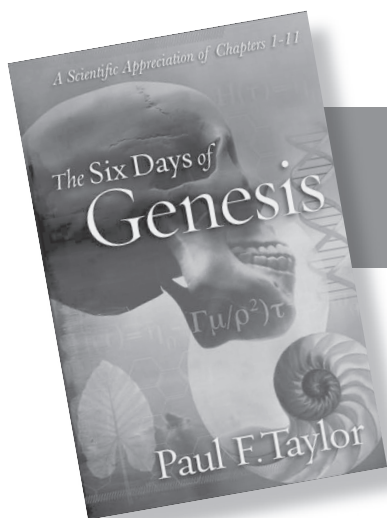
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Book Review

The Six Days of Genesis

by Paul F. Taylor

Master Books, Green Forest, AR, 2007, 221 pages, \$14.00.

Author Paul F. Taylor is a science teacher and speaker for Answers in Genesis in the U.K. He also edits the Answers Update section of the AIG website. This is not Paul S. Taylor of Eden Communications in Phoenix.

The book reviews the creationist position on Genesis 1–11. Taylor leans heavily on the ideas of Ken Ham, Russell Humphreys, and Henry Morris. Several novel ideas are also presented. Taylor suggests that Adam's entire task of naming the animals may have extended far beyond the sixth day. The Nephilim

(giants in KJV) named in Genesis 6:4 in the pre-Flood world are suggested to be large animals instead of people. Misuse of a weekly day for rest, reflection, and worship is proposed as a chief reason for stress in our world today.

Some errors need attention in the next book edition. The speed of light is given as 186,000 miles/hour, 3600 times too slow (p. 55). The sun's apparent motion across the sky is attributed to the earth's orbital motion, but the cause is earth's daily rotation (p. 52). Incorrectly, hydrogen is said to decay to helium (p.

132). Astronomers are said to believe that a global flood once covered Mars, but only area floods are proposed (p. 161). An interesting typo occurs on page 57.

Author Taylor presents a solid Christian testimony. The book has no figures but includes an index. Several creationist organizations are listed with no mention of the Creation Research Society, which predates them all.

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Unification of Fundamental Forces at High Radiation Temperature in the Creator, “The Consuming Fire”

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Abstract

Unification of the fundamental forces—gravity, electromagnetism, and the strong and weak nuclear forces, possibly at the quantum level—has been the highest quest of modern physics but has not been found in a set of field equations or “theory of everything.” These diverse forces of widely varying strengths using different constants and units are not reducible to a single phenomenon at the current low temperature state of the universe. An evolutionary, big bang origin of the universe is not advocated. Nevertheless, radiation temperature is shown to be a parameter of unification, and although introduction of this concept does not end in a comprehensive unified theory, it points to unification in the Creator, the God of the universe, in His singularity conditions, beyond natural law and quantification.

Introduction

“And to the eyes of the sons of Israel the appearance of the glory of the Lord was like a *consuming fire* on the mountain top.”

Exodus 24:17[†]

“And the mountain burned with fire to the *very heart* of the heavens ... For the Lord your God is a *consuming fire*.”

Deuteronomy 4:11, 24

“For our God is a *consuming fire*.”

Hebrews 12:29

Einstein’s dream, on which he worked for the last 36 years of his life, was to unify the fundamental laws of physics—gravitation, electromagnetism, and the nuclear forces—with quantum mechanics in one set of field equations. Abraham Pais, speaking of Einstein’s vision, said,

He was looking for a unified field theory, but to him that concept meant something different from what is meant and means to everyone else. He demanded that the theory be strictly causal, that it shall unify gravitation and electromagnetism, that the particles of physics shall emerge as special solutions of the general field equations, and that the quantum postulates *shall be a consequence* of the general field equations.” (Pais, 1982, p. 465).

Einstein himself said in 1949, “Our problem is that of finding the field equations of the total field.” (Pais, 1982, p. 465). Einstein failed in this quest, and there have been no complete candidate theories unifying all the forces with quantum mechanics. Again, from Pais’s definitive biography: “What drove Einstein to this search? ... the answer has to do with a grand design which Einstein conceived early, before the discovery of quantum mechanics ... of particles and fields in which general relativity and quantum theory would be

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[†] All Scripture references from the NEW AMERICAN STANDARD BIBLE, 1977, by the Lockman Foundation. Used by permission.

synthesized. This he failed to achieve. So to date ... an all-embracing theory does not exist" (Pais, 1982, p. 31). It may be that unification is ultimately realizable only in the nature of the Creator Himself.

Unification of the fundamental forces is postulated to exist at high temperature in theoretical models of the early universe and in the singularity conditions predicted inside a black hole. At high temperature, gravity, electromagnetism, and the nuclear forces may be unified due to the convergence of the values of the coupling constants for these different types of forces (Georgi, 1989; Dimopoulos, Raby, and Wilczek, 1991). Shielding of the core of a particle from other particles is thought to be the physical reason coupling constants vary with energy. A *coupling constant* is a number inserted in a theory to fix the strength of a force, for instance on a Feynman diagram. Unification of these diverse forces into one expression or source equation has been the enduring dream of physics, and unification may occur at high temperature. All interactions must be unified in this singularity condition, but the equation of this state as a source expression for all the fundamental forces has yet to be found. Analytically combining these distinct forces exerted over vastly differing distance ranges and strengths with unique constants and units has eluded physicists since Einstein, and has now become the search for a "theory of everything" that attempts to incorporate all physical phenomena into this one set of equations. The comprehensive description of unification is realizable only in the unapproachable nature of the Creator Himself. Radiation temperature, however, may provide a measure of unification.

Temperature is implicitly understood as the defining scale of unification since this state at high temperature is central to cosmological models in standard thermal histories of the universe. This article develops such a black-body equivalent unification temperature of fundamental constants where force distinctions break down, a "fusion temperature" of fundamental forces similar to Planck temperature, but as the result of gravitational, electromagnetic, and quantum arguments rather than from dimensional analysis alone. This is proposed as one scientific description of unification consistent with the revealed Creator of the Bible.

A Unification Source Temperature

To unify forces, we can begin to relate large-scale gravity with electromagnetic and nuclear forces with a simplification of the gravitational field equation of a point mass in terms of the curvature of space, $K(r)$, as

$$K(r) = -\frac{GM}{c^2 r^3} \quad (1)$$

(Berry, 1976, pp. 72–73). Using dimensional analysis, Berry shows that this equation for the curvature is the simplest one giving the spatial curvature near an isolated mass M , and which gives a curvature directly proportional to the mass M . According to dimensional analysis, equations are possible in which the curvature is proportional to a higher power of M ; however, according to Berry, equation (1) is the one that emerges rigorously from Einstein's field equations within the condition of non-oscillating spatial curvature near an isolated mass. If we then evaluate this curvature at the Schwarzschild radius of a black hole, $R_s = 2GM/c^2$, then

$$K(R_s) = -\frac{c^4}{8G^2 M^2} \quad (2)$$

where M is the total mass of the gravitational source inside R_s . This mass is equivalent to energy by Einstein's equation, so we can write for a mass, M , equivalent to radiant energy, $E = Mc^2 = aT^4V$ in a volume V where a is the radiation constant:

$$\frac{M}{V} = aT^4 / c^2 \quad (3)$$

Here mass density is equivalent to black-body radiation energy density at temperature $T(K)$ in a volume V , and, although a theoretical mass-energy transformation, it could be realizable at a high enough temperature. An example of this equivalence of mass and radiant energy is photon capture near a black hole. Since a black hole would gain a background radiation black-body photon at the Schwarzschild radius, then, by conservation of energy, the mass of the photon would increment the mass of the black hole. Photon energy is thus transformed into gravitational potential energy of the black hole at R_s , and is equivalent.

If we then let V in equation (3) be the Schwarzschild volume V_s , and with spherical geometry, $V_s = (4/3)\pi R_s^3 = M_s c^2 / aT_s^4$, transposing and combining this with equations (1) and (3) yields,

$$K(R_s) = -GM_s / c^2 R_s^3 = -4\pi aGT_s^4 / 3c^4 \quad (4)$$

And this means that from equations (2) and (4),

$$c^4 / 8G^2 M_s^2 = 4\pi aGT_s^4 / 3c^4 \quad (5)$$

Therefore,

$$T_s^4 = 3c^8 / 32\pi aG^3 M_s^2 \quad (6)$$

Here T_s is the estimated black-body radiation temperature inside R_s due to the compression of mass M_s into a black hole. This energy is not observable outside of R_s due to the trapping of all radiation inside the event horizon. Substituting for the radiation constant, $a = 8\pi^5 k^4 / 15c^3 h^3$, equation (6) becomes

$$T_s^4 = \frac{45c^{11}h^3}{256\pi^6 k^4 G^3 M_s^2} \quad (7)$$

where k and h are Boltzmann and Planck constants. Returning to the definition of the Schwarzschild radius, $M_s^2 = R_s^2 c^4 / 4G^2$, then

$$T_s^4 = \frac{45c^7 h^3}{64\pi^6 k^4 G R_s^2} \quad (8)$$

If we now let the Schwarzschild radius R_s collapse to the Compton wavelength of a particle, $\lambda_c = h/mc$, the fundamental limit on measuring the position of a particle of *rest mass*, m ; then R_s now approaches the length scale where a relativistic quantum field theory becomes necessary for a complete description. This is the shortest quantifiable distance consistent with Heisenberg uncertainty, and for an electron as the smallest rest mass particle that has electric charge and can be acted upon by gravity. The electron cannot be localized within a shorter length than λ_{ce} . The Compton wavelength can be considered the junction length of classical, relativistic, and quantum mechanics, therefore λ_c is the limit to which R_s can be reduced. Substituting the electron Compton wavelength λ_{ce} for R :

$$T_{uce} = \left(\frac{45c^7 h^3}{64\pi^6 k^4 G \lambda_{ce}^2} \right)^{1/4} = \left(\frac{c^9 h m_e^2}{1.42 \pi^6 k^4 G} \right)^{1/4} = 2.4 \times 10^{20} \text{ K} \quad (9)$$

This is the estimated unification temperature inside R_s reduced to the limit of the Compton wavelength of the electron to couple gravity with electromagnetic interactions. This is a unique equation of all constants derived from classical, relativistic, and quantum-radiation arguments, and not dimensional analysis alone as in the case of Planck temperature. The Compton wavelength of the electron is first used as the smallest rest mass, charged particle fundamental to all matter, and the energy exchange particle of quantum-electromagnetic interactions. To extend this to nuclear interactions and the “strong” force, at the other end of the real particle spectrum is the proton, the largest stable rest mass particle (the neutron is not stable unless it is bound inside a nucleus) fundamental to all matter beginning with the hydrogen atom. Now, substituting the proton Compton wavelength of the nucleus, λ_{cp} , for

λ_{ce} in equation (9) to further reduce the event horizon to the characteristic length scale of nuclear interactions, then

$$T_{ucp} = \left(\frac{c^7 h^3}{1.42 \pi^6 \lambda_{cp}^2 k^4 G} \right)^{1/4} = 1.02 \times 10^{22} \text{ K} \quad (10)$$

This is an equation of all the constants of the fundamental forces and quantum mechanics yielding a very high temperature to attain unification conditions at the scale of the Compton wavelength of the proton. The proton is chosen as the rest mass particle basic to all the elements at the heart of matter, the nucleus, where λ_{cp} is the fundamental interaction length of the strong nuclear force. This equation may define a fundamental temperature in the singularity where all forces must be unified at the intersection of gravity, relativity, electromagnetic, and nuclear interactions and quantum mechanics; a quantum-radiation temperature relation between the fundamental forces of nature. *Equation (10) is a unifying concept for gravity, electromagnetism, and the nuclear forces where they become equal, where one constant incorporates all the forces. This means that these forces are the same phenomena at this high temperature.*

It should be noted that there is not universal agreement with equating the Schwarzschild radius with the Compton wavelength of a particle, although $h/mc = 2Gm/c^2$ is the generally accepted step in the definition of Planck mass, “Planck particles,” and other Planck limit quantities. In their recent paper, “Planck Particles and Quantum Gravity” Crothers and Dunning-Davies (2006, pp. 70–73), question whether this is an adequate basis for defining Planck particles, which they state may not exist, and the physical relevance of equating the Compton wavelength (“which is Euclidean”) with the Schwarzschild radius (“inherently non-Euclidean”). However, the Schwarzschild radius is an established definition of the event horizon of a black hole, and this paper is not defining “Planck particles” or asserting their existence, but using R_s and λ_c as established physical boundaries; and both can be described as Euclidean as the authors state on page 71 of their paper. The Schwarzschild radius and Compton scale are used here as well-defined limits.

It is postulated in the standard model of particle physics that at some high temperature, force distinctions break down (e.g. see Roos, 2003, pp. 176–177). This is quantified in equation (10), resulting in a temperature in the unification region but below Planck temperature ($T_{pl} = E_{pl}/k = m_{pl}c^2/k = (hc^5/2\pi Gk^2)^{1/2} = 1.42 \times 10^{32} \text{ K}$). This radiation temperature may be a threshold where fundamental forces become unified or “fuse” in the singularity of the black hole, where forces lose distinction at the limit where gravity meets quantum physics at a high black-body radiation temperature. Although advo-

cating an evolutionary, big bang origin for the universe over billions of years would be a mistake and is not being proposed here, there nevertheless seems to be a physical basis for this “unification temperature.”

Analysis of a Unification Temperature

The black-body-equivalent radiation temperature of 10^{22} K of equation (10) is a high temperature in theoretical thermal histories of the universe. At 10^{11} K corresponding to a mean energy of 300 MeV, according to Roos, the primordial hot plasma had cooled sufficiently for nucleosynthesis of the elements (Roos, 2003, p. 130). (Absolute temperature is here a measure of average energy by the dimensional relation $E = kT$ where k is Boltzmann's constant.) In standard model nucleosynthesis, nuclear fusion reactions occur in the range of 2.22–7.72 MeV (Roos, 2003, p. 140). So, after some primordial phase transitions occurring in some current theories of the early universe, temperature is the defining parameter at $E \approx 200$ MeV or $T(K) = 2.32 \times 10^{12}$ K as theorized by Roos and others (Roos, 2003, p. 172).

Projecting to temperatures and energies greater than 10^{12} K or 200–300 MeV, grand unified theory (GUT) interactions begin. The unification of weak nuclear and electromagnetic forces in the electroweak interaction is thought to occur as the temperature increases through 10^{15} K in the energy range of 1–100 GeV (Roos, 2003, pp. 173–174), resulting in a “thermal soup of quarks, gluons, leptons, and photons.” This is the theoretical mass-energy transformation range of W and Z particles and the Higgs boson, according to Roos, and at this energy there is no distinction between weak nuclear and electromagnetic interactions. If we continue this temperature rise to 10^{16} K at 10^3 GeV or 1 TeV, this is now the range where our models of the universe are no longer testable through experiment due to the limits of present-day accelerators. Here we encounter phase transitions beyond electroweak interactions and reach the threshold of supersymmetry (SUSY) theory. Still higher are $1\text{--}10^{12}$ TeV energies corresponding to temperatures of $10^{16}\text{--}10^{28}$ K, which bound the 10^{22} K temperature of equation (10). This is the threshold of “new physics” required in this energy range, since no known laws of physics hold here (Roos, 2003, pp. 174–176). Above this is 10^{12} GeV $< E < 10^{16}$ TeV, or 10^{19} GeV on the energy scale as the upper energy limit corresponding to the Planck temperature of 1.16×10^{32} K. This is the theoretical limit where GUTs and unification and breakdown of all forces has occurred, but it requires introducing large numbers of new particles, vector bosons and Higgs scalars, all of which are yet to be discovered (Roos, 2003, p. 177). 10^{19} GeV is the Planck limit where gravitational and quantum effects are of equal importance. The 10^{22} K result is therefore consistent with

creation nucleosynthesis and thermal models of the universe as a possible unification threshold temperature.

Finally, it is significant to see how the derived unification temperature compares with recent experiments to create a quark-gluon plasma (QGP) reported at Brookhaven National Laboratory in the Relativistic Heavy Ion Collider (RHIC). Experiments in the RHIC are intended to break down fundamental particles such as protons in high-energy nucleon collisions, and this is to induce phase transitions from ordinary nucleon or hadronic matter states into constituent quarks and gluons in a QGP generally thought to be the state of the early universe. Results are preliminary as to whether a large density of quarks and gluons, or “partons” has been created yet (Arsene et al, 2005, p.2). These researchers define a critical temperature in which these intended phase transitions should occur, $T_c \approx 175$ MeV (or less than 10^{12} K), based on the fundamental theory of strong interactions and quantum chromodynamics, but they state it is not at all clear whether transition to the QGP has occurred (Arsene et al, 2005, p. 4). These results from the first round of RHIC experiments clearly show that high-energy nucleon-nucleon collisions have moved to a “qualitatively new physics domain” and that relative abundances of many different particles containing the “three lightest quark flavors” were achieved at a temperature in the vicinity of $T = 175$ MeV (Arsene et al, 2005, p. 26). From this it is apparent experimentally that QGP phase transitions begin at energies around 175 MeV with the identification of some quarks, but complete phase transition to a QGP has not occurred at this energy level, which corresponds to a temperature of 10^{12} K, below the derived threshold unification temperature of 10^{22} K of equation (10). Higher energies at RHIC and in other accelerators should clarify these phase transition temperatures in the future.

High-Temperature Unification as an Aspect of God's Manifest Nature and Glory as “The Consuming Fire”

There are numerous references in both the Old and New Testaments to high-temperature, bright thermal radiation as a fundamental aspect of God's revealed nature. His infinite, manifold attributes are much beyond His observable radiance in these cases, but it is apparent that thermal radiation is integral to His manifest glory. The first revelation of God to the Israelites during the Exodus was as a pillar of cloud by day and pillar of fire by night (Exod. 13:21; 14:19–20; Num. 14:14; Deut. 1:33; Neh. 9:12, 19; Ps. 78:14), and in Exodus 24:17, where they first see His glory manifested as fire on Mount Sinai, Moses records “And to the eyes of the sons of Israel the appearance of the glory of the Lord was like a consuming fire on the mountain top.” The only analogy they

can make observationally is to describe Him as a “consuming fire,” or devouring fire that entirely consumes. This follows from God’s earlier visit to Mount Sinai as recorded in Exodus 19:18: “Now Mount Sinai was all in smoke because the Lord descended upon it in fire.” Fire is the most striking attribute of His nature. A parallel passage is Deuteronomy 4:11–12 reads, “*The mountain (Mount Sinai) burned with fire to the very heart of the heavens ... Then the Lord spoke to you from the midst of the fire*” (emphases added), reiterating this aspect of God’s presence. In the New Testament, Hebrews 12:29 declares, “For our God is a consuming fire.”

The fact that God Himself *is* a consuming fire, cited in both the Old and New Testaments, shows how central this is to His nature. Another passage linking bright thermal radiation to the nature of God is Ezekiel 1:1, where the prophet declares, “The heavens were opened and I saw visions of God,” and later in verse four, “As I looked, behold, a storm wind was coming from the north, a great cloud with fire flashing forth continually and a bright light around it, *and in its midst something like glowing metal in the midst of the fire*” (emphasis added). This is a clear reference to God’s manifest glory in thermal radiation, “something like glowing metal.” Later in Ezekiel 1:26–28 we read, “Now above the expanse that was over their heads there was something resembling a throne, ... and on that which resembled a throne, high up, was a figure with the appearance of a man ... from the appearance of His loins and upward *something like glowing metal that looked like fire all around within it, and from the appearance of His loins and downward I saw something like fire; and there was a radiance around Him ... Such was the appearance of the likeness of the glory of the Lord*” (emphases added). Ezekiel is recording the indescribable God of glory in definitive thermal radiation terms.

Unification of fundamental forces at high radiation temperature proves that the unified source of those forces is the God of the universe, the Consuming Fire. High radiation temperature in this connection is a manifestation of His nature recorded in Scripture from Exodus to Hebrews: “The God who answers by fire, He is God” (1 Kings 18:24); “Then the fire of the Lord fell” (1 Kings 18:38). Both Psalm 104:4 and Heb. 1:7 speak of, “flaming fire His ministers,” and in Psalm 18:8, “Fire from His mouth devoured; coals were kindled by it,” is another reference to radiant thermal energy. Isaiah 29:6 speaks of “the flame of a consuming fire,” and Isaiah 30:30 says, “And the Lord will cause His voice of authority to be heard ... and in the flame of a consuming fire.” This relationship between God as a consuming fire and His creation and origin of the fundamental forces is best summarized in 2 Peter 3:10 and 12 regarding the future day of the Lord “when the Lord Jesus shall be revealed from heaven with His mighty angels in flaming fire” (2 Thess. 1:7): “But the

day of the Lord will come like a thief, in which the heavens will pass away with a roar and the elements will be destroyed with intense heat ... the day of God, on account of which the heavens will be destroyed by burning, and the elements will melt with intense heat!” This is the ultimate destruction of the universe from the grandest scale of the heavens (gravity, electromagnetic radiation) to the smallest scale of the elements (nuclear, quantum-electromagnetic forces), where these forces are fused together by thermal radiant energy and the elements melt down or melt together. Temperature is a unifying parameter that spans from the heavens to the elements, the fundamental particles, and is the agent of their ultimate dissolution. These forces are necessarily unified in this state from God Himself, the ultimate singularity, and this is the connection between the Creator of the universe as the unified source of fundamental forces and His nature as a consuming fire.

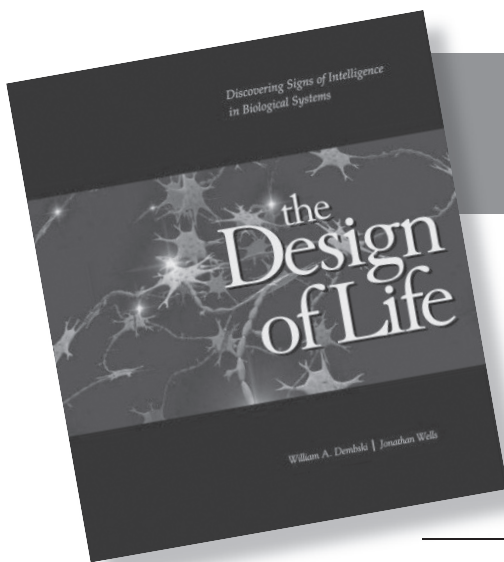
Summary

The result of equation (10) is a black-body-equivalent radiation temperature describing unification conditions inside the Schwarzschild event horizon reduced to the Compton quantum wavelength scale of the fundamental stable, rest mass nucleon, the proton. This is a real temperature based on more constants than Planck temperature: c , h , k , G , and λ_{cp} , which are fundamental to relativity, quantum mechanics and electromagnetic radiation, thermodynamics, and gravity. Equation (10) may be a radiant energy source expression for fundamental forces, since it incorporates all the force constants and shows that the underlying connection between forces may be thermal in nature with $T(K)$ the unifying parameter. This is also suggested by scriptural references to the Creator as “the Consuming Fire” and source of thermal consummation of all things. Unification of forces will never be found in a “theory of everything” but only understood in the nature and attributes of the “God of everything,” the Creator of the universe revealed in the Scriptures. Unification at high radiation temperature is a basis for quantifying unification of forces in terms of temperature at the junction of these force domains where unification occurs and is described by fundamental constants. Inside the event horizon of a black hole, an extremely warped space-time is thought to exist, which would be all that is left of the matter that crossed the event horizon and descended to its end at the singularity. We cannot observe what happens inside a black hole and live; similarly Scripture states that no man can see God and live (Exodus 33:20; cf. John 1:18).

The unified source of all force interactions, discoverable only at the extreme limits of radiation temperature, is God Himself, the Creator and Sustainer of the universe.

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Book Review

The Design of Life: Discovering Signs of Intelligence in Biological Systems

by William A. Dembski and Jonathan Wells

The Foundation for Thought and Ethics, Dallas, 2008. 361 pages, \$35.00.

The Design of Life (DOL) should be read not only by those who think that evolution (Darwinism) is the best viewpoint, but also by anti-Darwinians, who will encounter additional evidence supporting their position. DOL is the sequel to *Of Pandas and People* (1993), in which intelligent design (ID) had been proposed “as a scientific alternative to Darwinian evolution” (DOL, p. xv).

Both of the above books were commissioned by Jon A. Buell, president of The Foundation for Thought and Ethics in Dallas. The first book was more tentative; DOL is thorough. A solid foundation for ID now is in place.

Coverage in DOL includes a dedication honoring Drs. Paul and Margaret Brand, a forward by W. S. Harris, and a preface by J. A. Buell. Topics include the meanings of evolution, human origins, genetics and macroevolution, the fossil record, the origin of species, similar features, irreducible complexity, specified complexity, the origin of life, and an epilogue

discussing “Inherit the Wind,” “The Santorum Amendment,” and “*Kitzmiller v. Dover*.”

There are 32 pages of endnotes, a 13-page glossary, and a 15-page index citing topics in the book and additionally on the accompanying CD, which greatly supplements the endnotes. I opened the CD using Adobe Reader 8. Following the index is one page about the authors and two pages of credits. Discussion questions are located at the chapter ends of DOL. The book is adorned throughout with color photographs, drawings, and backgrounds.

DOL is scholarly and a very appropriate gift for libraries, scientists, and discerning layperson friends and relatives.

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Where Is the Pre-Flood/Flood Boundary?

Michael Oard and Carl Froede, Jr.*

Abstract

Five discontinuity criteria have been proposed as tools in an effort to locate the pre-Flood/Flood boundary. On the basis of these criteria, a boundary has been proposed high in the Precambrian section for the eastern Grand Canyon and about midway in the Precambrian section of the eastern Mojave Desert. Examination of these criteria, based on certain assumptions of the pre-Flood world, suggests that changes should be considered for both the criteria and previously proposed boundaries. In general, the pre-Flood/Flood boundary is likely to occur lower in the strata—probably close to the top of the igneous/metamorphic basement.

Introduction

Identifying the pre-Flood/Flood boundary affects both the identification of pre-Flood strata and any interpretation of early Flood catastrophism. Traditionally, this boundary has been placed at the Precambrian/Cambrian (Pc/C) contact (Austin, 1994), an assignment that assumes the chronostratigraphic validity of the uniformitarian geological column. Baumgardner (2005) stated, “Included in the list are a number of samples from the Precambrian, that is, what we consider non-organic pre-Flood settings” (p. 594).

There are several reasons for adopting the Pc/C contact, primarily because of the substantial increase in the number and complexity of Cambrian fossils. This sudden appearance of organic life-

forms is called the “Cambrian Explosion” (Meyer et al., 2003) and marks the sudden stratigraphic appearance of complex multicellular organisms. Snelling (2005, p. 125) writes:

There is a widespread consensus that the evidence for the commencement of the Flood in the geologic record is where the strata containing fossilized multi-cellular organisms begin, and that is confirmed by the associated evidence of catastrophic deposition of those and other sedimentary strata.

Snelling (1991) formerly believed that most Precambrian sedimentary rocks were from the Flood, but he has since changed his mind (Wise and Snelling, 2005).

However, complex animals, such as the multicellular Ediacaran fossils, are

increasingly found in the late Precambrian. Even embryos, likely of multicellular organisms, are found in late Precambrian rocks (Hagadorn et al., 2006). This has caused Wise (1992; 2003) to lower his pre-Flood/Flood boundary to the upper Precambrian.

But what if such a paleontological discontinuity was caused by depositional conditions within the Flood? If so, the pre-Flood/Flood boundary could be significantly lower in the geological column (Froede and Oard, 2007).

The Discontinuity Criteria

Austin and Wise (1994) and Wise and Snelling (2005) proposed a pre-Flood/Flood boundary in the eastern Grand Canyon (Figure 1) at a stratigraphic level a little below the Pc/C contact, based on five “discontinuity” criteria. Since any one of these criteria is usually equivocal, multiple confirmatory criteria would be preferred. Wise and Snelling (2005) placed the boundary just below the late Precambrian Sixtymile Formation,

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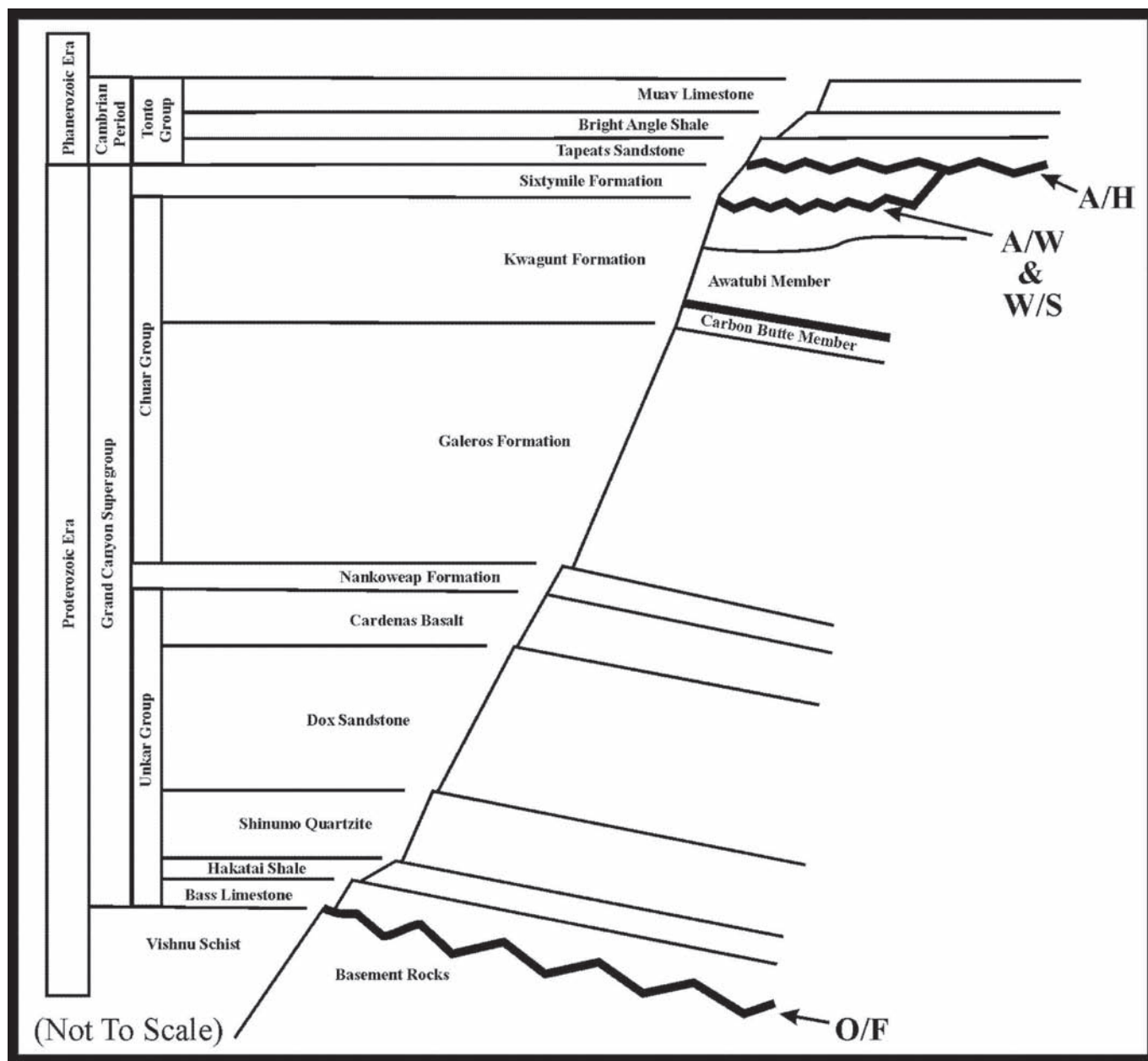


Figure 1. A composite cross section of the lower section of Grand Canyon (modified from Elston, 1989, p. 261). The three different pre-Flood/Flood boundaries are indicated by the arrows: A/H – Austin (1994) and Hoesch (2007); A/W – Austin and Wise (1994); W/S – Wise and Snelling (2005); and O/F – Oard and Froede (this paper). The Great Unconformity was originally proposed as the pre-Flood/Flood boundary. Based on the five discontinuity criteria, the boundary is proposed to exist deeper within the Canyon—not at the base of the Cambrian, not at the Upper Precambrian Sixtymile Formation, but at the base of the Sixtymile Formation.

which represents the top formation in a 4-km thick Precambrian sedimentary succession.

In the eastern Mojave Desert near Death Valley, the boundary is placed in

the lower Kingston Peak Formation (Austin and Wise, 1994; Wise, 2003) about 4 km below the top of the Precambrian and approximately 2 km above the crystalline basement. The upper and middle

Kingston Peak Formation consists mostly of diamictite, an unsorted or poorly sorted, sedimentary rock with a wide range of particle sizes. Uniformitarian geologists consider the diamictite an an-

cient ice-age deposit, while creationists consider it a massive submarine landslide formed during the Flood (Oard 1997; Sigler and Wingerden 1998; Wise, 1992). Wingerden (2003) has extended the pre-Flood/Flood boundary within the Kingston Peak Formation northward into Utah and Idaho just below Precambrian diamictites.

The five discontinuity criteria proposed by Austin and Wise (1994) and amplified by others represent a good starting point for further discussion. Each discontinuity criterion will be discussed in general and applied to the eastern Grand Canyon and Mojave Desert.

What Do We Know about the Pre-Flood World?

Understanding how to use these criteria would be easier if we knew the type and scale of geological activity before the Flood. However, the geological evidence is uncertain since there is no clear stratigraphic demarcation of the pre-Flood world. We do know that the topography and the geography of the pre-Flood world were *unlike* today, because the Flood catastrophe destroyed the earth's surface (Gen. 6:13). Differential vertical tectonic movements measured in miles combined with the erosion, transport, and deposition of an average of 1.5 km of strata on the present continents occurred during the Flood. It is even possible that there were rapid, large-scale horizontal dislocations of lithosphere during the Flood (e.g., catastrophic plate tectonics, hydroplate), though the evidence presented to date is less than compelling (Reed, 2000a; Akridge et al., 2007). Thus, the Bible must provide clues about the early earth to constrain geological and paleontological evidence.

On Day 3 of the Creation week, God separated the dry land from the waters below (Gen. 1:9). Some creationists believe that this event was accompanied

by great geological activity such as the deposition of thick sediments (Austin, 1994). However, since the creation was by definition a supernatural activity, the dry land could have appeared absent geological upheavals, and their subsequent erosion, transport, and deposition of sediments. For the sake of argument, we will assume the formation of some sedimentary sequences on Day 3.

Some creationists also assume that since the creation of bacteria is not mentioned in Genesis 1, they could have been created on Day 2 or 3 (Wise, 2002). The Bible is also not specific about the appearance of marine blue-green algae (cyanobacteria), but presumably they also could have been created at the same time as the bacteria. Thus, both bacteria and blue-green algae (unicellular, prokaryotic organisms) could have been created before the dry land appeared and thus *buried* if there was depositional activity on or after Day 3. Those rocks could potentially contain fossils of bacteria and algae, but nothing more since land plants were created following the emergence of land on Day 3 (Gen. 1:11) and the rest of the animals were created during Days 5 and 6. We would not expect any land plants or multicellular animals in Day 3 strata (if any).

However, there are differences of opinion about the timing of creation of bacteria and algae. Walker (1994) favored their creation on Day 5, along with the other ocean creatures, but he admits that they could have been created on Day 3 with the terrestrial vegetation. Whether created on Day 2, 3, or 5, Walker (1994) believes bacteria and algae were created *after* the dry land appeared. Thus, he would predict the total absence of microfossils of bacteria or blue-green algae in the Day 3 strata, if any were deposited. Due to the paucity of data, any opinion is speculative.

Though unexpected on the earth as created ("very good"), catastrophic natural disasters could have occurred following the Curse. Did the Curse per

se result in natural disasters prior to the Flood, or would a relatively uniform climate, hydrology, tectonics, etc. have continued as created? Walker (1994) and Reed et al. (1996) suggest that the pre-Flood earth was rather placid geologically. Geological reasoning could be applied only if we knew the stratigraphic boundaries of Day 3 rocks (if any), the antediluvian world, and the Flood.

The Bible suggests that the early Flood was the most geologically intense phase; the fountains of the great deep were broken and the windows of heaven opened, all on a global scale. Although there is some divergence of opinion on the precise meaning of the fountains of the great deep, most creationists believe that the crust of the earth was broken up and the ocean water rose. The lead author leans toward the idea that the fountains of the great deep were caused by thousands of meteorite impacts. The windows of the heavens imply heavy rain for 40 days and nights, which in the view of the lead author would easily occur if meteorites hit the pre-Flood ocean, blasting water up into and above the atmosphere. The rain abated after 40 days, and it is reasonable to suggest that the initial tectonic upheavals also abated. Figure 2 shows a chart of the geological energy levels during the Flood (Reed et al., 1996; 2006).

Thus, the following discussions of the lower Flood boundary and the discontinuity criteria must be tempered by the historical uncertainty inherent in the problem. That aside, do the discontinuity criteria offer a definitive means of identifying this important boundary at Grand Canyon and the eastern Mohave Desert?

Paleontological Discontinuity

The first criterion is a paleontological discontinuity—traditionally considered the most significant in determining the boundary. It is based on a transition from unicellular to multicellular fossils. In eastern Grand Canyon and the eastern

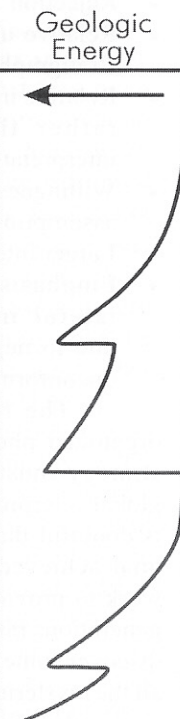
1		2	3		4					
Era	Period	Geologic Energy	Timeframe Division		Event / Era Stage		Duration	Phase		
Cenozoic	Quaternary		Present Age	Upper	Postdiluvian Era		4,000 Y	Modern		
	Middle									
	Lower									
Tertiary	Ice Age		Upper	300 Y			Residual			
			Middle							
			Lower							
Mesozoic	Cretaceous		Flood Event	Upper	The Deluge	Recessive	220 D	Dispersive		
	Jurassic			Middle				Abative		
	Triassic			Lower	Inundatory	110 D	Zenithic			
Paleozoic	Permian		Creation Week				The Creation Event	Formative	2 D	Biotic
	Pennsylvanian			Day 7	2 D	Derivative				
	Mississippian			Day 6						
	Devonian		Day 5	2 D	Ensuing					
	Silurian		Day 4							
	Ordovician	Day 3								
	Cambrian	Day 2	0 D	Primordial						
Vendian	Day 1									
Proterozoic										
Archaean										

Figure 2. Comparison of stratigraphic interpretive frameworks between (1) the uniformitarian stratigraphic column, (2) geological energy versus time (Reed et al., 1996), (3) Froede's (1995) classification, and (4) Walker's (1994) classification (from Reed et al, 2006, p. 138).

Mojave Desert, "stromatolites" and microfossils are found in the Precambrian sedimentary rocks both above and below the proposed pre-Flood/Flood boundaries of Austin and Wise (1994) and Wise and Snelling (2005). The Sixtymile Formation is unfossiliferous (Wise and Snelling, 2005), while the Paleozoic formations above the Sixtymile Formation contain multicellular organisms. Therefore, the pre-Flood/Flood boundary would have been better placed at the top of the Sixtymile Formation based strictly on the paleontological discontinuity.

The paleontological discontinuity hinges on the status of the stromatolites and microfossils in the Precambrian below the boundary, and interpretations of the events of Day 3 and the nature of the pre-Flood world influence where the boundary is placed.

1. "Stromatolites" Below the Pre-Flood/Flood Boundary

"Stromatolites" are reported in Precambrian formations below the currently proposed pre-Flood/Flood boundary in eastern Grand Canyon and eastern Mojave Desert. They are found as deep as the first formation above the igneous/metamorphic basement rocks, the Bass Limestone. They are also found in the Dox and Kwagunt formations (Hendricks and Stevenson, 1990). Wise and Snelling (2005) proposed that stromatolites in the Kwagunt Formation, 635 m below the base of the Sixtymile Formation, help define the pre-Flood/Flood boundary because they supposedly developed over a relatively long period of time before the Flood.

In the eastern Mojave Desert, stromatolites are found in the Beck Springs

Dolomite, the second formation above the basement and just below the proposed boundary (Tucker, 1983).

There are at least nine reasons why creationists need to be cautious in assuming these stromatolites are biogenic and thus could not have been rapidly formed (see Appendix 1).

2. Microfossils Below the Pre-Flood/Flood Boundary

The paleontological discontinuity also rests on the stratigraphic position of microfossils relative to the proposed boundaries. Microfossils are found in the eastern Grand Canyon and the eastern Mojave Desert in the Precambrian formations below the proposed boundary of Wise and Snelling (2005). For instance, more advanced eukaryote fossils are found in the Beck Springs

Dolomite in the eastern Mojave Desert (Wise, 2003). The Kwagunt Formation just below the Sixtymile Formation also contains fossils of cyanobacteria.

More and more microfossils are being found worldwide in Precambrian sedimentary rocks, even in those considered early Precambrian. The presence of microorganisms was a major factor in Snelling's (1991) early belief that some Precambrian sedimentary rocks were deposited by the Flood. Although microfossils can often be confused with abiogenic structures, research is progressing, and presumably the ability to recognize microfossils is improving. Schopf (2006) reported 40 microfossil localities in Archean (older than 2.5 billion years) sedimentary rocks. Even eukaryote fossils are found in rocks dated at 2.7 billion years (Oard, 2001). The Proterozoic (2.5 to 0.5 billion years) includes many sediments containing microfossils.

The significance of "Precambrian" microfossils is uncertain. They are found in thick, widespread Precambrian sedimentary rocks that strongly suggest regional catastrophic deposition. There are two compelling reasons to think that these may be Flood deposits. First, the strata in question are thick accumulations of sediment, consistent with deposition in the Flood (see Appendix 1). Second, if the microfossils represent pre-Flood fossilization, it is reasonable to ask why there are *no* fossils of multicellular organisms associated with the microfossils. It seems more reasonable to assume that "Precambrian" microorganisms were fossilized in the Flood. In many locales, this would push the pre-Flood/Flood boundary to the contact between Precambrian sedimentary rocks and the crystalline basement rocks.

The absence of Precambrian multicellular fossils also presents a problem for the Flood model. Perhaps factors associated with the onset of the Flood, such as intense turbulence, heat, volcanism, or metamorphism (Hunter, 1992)

precluded preservation of multicellular fossils. Perhaps the earliest phase of the Flood was so violent in certain locales such as rift basins, that multicellular organisms were pulverized. Or they could have been transported away by powerful currents or sediment gravity flows. Furthermore, just because a formation is unfossiliferous does not mean that the formation is not from the Flood. Even some Phanerozoic sedimentary rocks (younger than 0.5 billion years) are strangely unfossiliferous (Peters, 2007). There must be a source of organisms in addition to sediment to preserve fossils. In short, the paleontologic discontinuity is not definitive.

Erosional Discontinuity

The second criterion cited is an erosional discontinuity—the presence of a widespread and significant erosional surface representing the early scouring action of floodwaters. It is a reasonable expectation for many areas because of highly energetic hydraulic flows expected with the initiation of the Flood. Large-scale erosion and deposition, especially combined with tectonics, would have created widespread unconformities.

But it is simplistic to attribute identical processes everywhere at the same time. Flat-lying pre-Flood strata, protected from the initial onslaught of the Flood (e.g., in a deep basin), could be conformable with early Flood sediments. Some sedimentary basins might show no signs of a significant erosional discontinuity. Clearly, none of the discontinuity criteria are absolute.

Wise and Snelling (2005) noted that the unconformity between igneous/metamorphic rocks and sedimentary rocks in the eastern Grand Canyon (Figure 3) is *the most significant unconformity* in the area. It is called the "Greatest Unconformity" and occurs deeper than the "Great Unconformity" below Precambrian sedimentary rocks. The Greatest Unconformity is an erosion surface capped in places by conglomerate or

breccia. We believe this contact better fits the criteria for the pre-Flood/Flood boundary. It merges with the Great Unconformity at the base of the Tapeats Sandstone in the western and central Grand Canyon.

Time Discontinuity

We reject the Austin and Wise (1994) "time discontinuity" as a *field* indicator of the pre-Flood boundary because it must be *interpreted*, not observed. Any "time discontinuity" will be subjective and potentially influenced by uniformitarian assumptions. Furthermore, tremendous tectonic forces and considerable erosion could have occurred anytime during the Flood. So, the duration of any proposed time discontinuity could be at any time during the Flood, depending on the local conditions. If forced to pick a time discontinuity, we would favor the *lowest*. In the eastern Grand Canyon and Mojave Desert, that would be at or near the top of the igneous and metamorphic basement.

Wise and Snelling (2005) stated that pre-Flood sediments had more time to lithify while Flood sediments experienced only limited lithification in the course of the yearlong Flood. So they would not expect erosion of early Flood sediments to generate significant conglomerates or breccias. Given that assumption, any thick conglomerate or breccia would suggest a time discontinuity between the deposits containing the clasts and the underlying source strata, and the pre-Flood/Flood boundary would then be defined immediately beneath the conglomerate or breccia. The large number and size of the clasts in conglomerates and breccias in the Sixtymile Formation in the eastern Grand Canyon and the Kingston Peak Formation in the eastern Mojave Desert have been cited as evidence for a significant time discontinuity. But if their assumption about lithification rates is incorrect, so is their interpretation of the boundary (see Appendix 2).



Figure 3. Two unconformities in Grand Canyon (view north from Moran Point, South Rim). The Great Unconformity is the contact between the horizontal strata above and the eastward dipping Precambrian strata below (horizontal line). The Greatest Unconformity is the boundary between the Precambrian strata and the underlying igneous/metamorphic rocks (line slanting to the right).

Even if the assumption regarding breccia and conglomerate clasts were true, the boundary should not be based on clast size, which is not a time indicator. The varying energy levels of the Flood at different locations could have produced any size clasts, even small clasts. Or energetic transport of eroded clasts, even over a short distance, could have deposited them higher in the sedimentary column in another location. For instance, a downfaulted basin could collect several kilometers of early Flood sedimentation (e.g., Grand Canyon Supergroup). Then a tectonic

event nearby could spread breccia or conglomerate from pre-Flood rocks over those sediments. Variations in elevation, proximity to source areas, current velocity, etc. would ultimately control clast size and stratigraphic position. Clasts alone cannot serve as a deterministic indicator.

Sedimentary Discontinuity

The base of a fining upward sedimentary sequence has also been suggested as a defining criterion for determining the pre-Flood/Flood boundary (Wise and Snelling, 2005). Since the base of the

Sixtymile Formation (a conglomerate) is also the base of a fining upward sequence in Grand Canyon, they believe that it marks the pre-Flood boundary. The overlying Tonto Group consists of the basal Tapeats Sandstone, a coarse stone with layers of quartz pebbles (Figure 4), which in turn is overlain by the Bright Angel Shale and then the Muav limestone.

That is the problem. Fining upwards sequences are caused by hydraulic conditions that could have existed at any time during the Flood. Such a sequence can be formed when a current deceler-

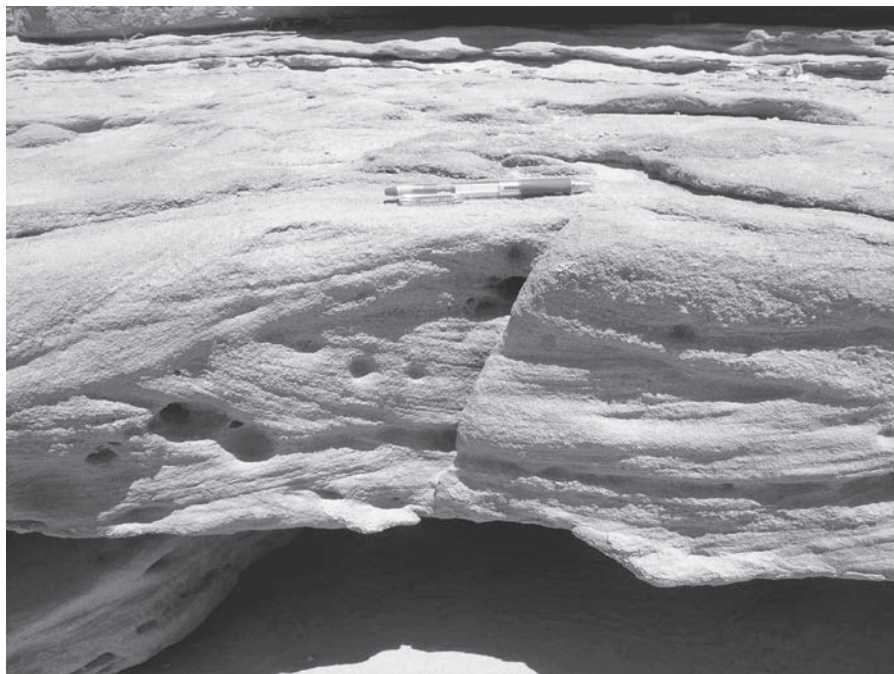


Figure 4. The coarse Tapeats Sandstone with pebbles at the mouth of the Little Colorado River.

ates or when sufficient sediment is added to a current, forcing deposition. The latter case is similar to a fining upward turbidity current, but on a large scale.

Since the initial stages of the Flood would very likely have been the most violent (see Figure 2), fining upward sequences would likely have been less common. One location where fine-grained sediments might have occurred very early in the Flood is in deep basins. Strong currents could have spread sediments into the basin from above, where the sediments settled into an area of weak currents within the basin or rift zone. The rapidly subsiding basins of the eastern Mojave Desert and the eastern Grand Canyon might well have generated a *coarsening* upwards sequence that would define the basal Flood boundary.

The fining-upward Tonto Group in Grand Canyon areas likely represent a subcontinental-wide sedimentation event and not a localized deep basin deposit (Morris, 2000). Such a laterally

extensive sedimentation event would probably not represent the onset of the Flood, since the first widespread sedimentation across North America would have followed sedimentation in deep rift basins formed at the very outset of the Flood. Such a widespread layer would likely represent a time when the mechanism of the Flood waned. Thus, it is *difficult to be specific* as to what would be a reasonable sedimentary discontinuity criterion for the boundary.

Tectonic Discontinuity

The earliest stage of the Flood probably included significant tectonic activity, but it might not have occurred everywhere at the same time. Moreover, tectonic activity apparently continued throughout the Flood. Thus, more than one tectonic discontinuity would be expected within the same region.

If the onset of the Flood was marked by rifting of basement igneous and metamorphic rocks (Reed, 2000b), and since the Precambrian sedimentary rocks in

the eastern Grand Canyon were deposited in a north-south rift (Karlstrom et al., 2000), then they could have been part of this early Flood rifting.

However, in most places, the initial stages of the Flood would have deposited sediments above an eroded granitic basement absent any sign of tectonism or strong currents. Later tectonism could have deformed those deposits. In that case, the pre-Flood/Flood boundary could be well below the first evidence of a tectonic episode. This illustrates again that none of these criteria are absolute. If anything, the tectonic discontinuity marking the basal Flood surface should be the lowest in the section. This would suggest that the most appropriate place to locate a pre-Flood/Flood “tectonic discontinuity” is at or near the contact between the clastic sediments and underlying basement igneous/metamorphic rocks.

Is the Boundary Located below Diamictite?

In the eastern Mojave Desert, the diamictite of the Kingston Peak Formation represents a tectonic, erosional, and sedimentological discontinuity (Austin and Wise, 1994; Sigler and Wingerden, 1998). Similar Precambrian diamictites are found in the western United States.

The Kingston Peak Formation, which lies above fine-grained sediments, may not be the basal Flood deposit. Earlier Flood fine-grained sediment could have been deposited prior to the diamictite. Moreover, there are other diamictites stratigraphically older elsewhere (Oard, 1997). Some diamictites are dated older than 2 billion years within the uniformitarian geological timescale. There are also younger diamictites—in the Ordovician and late Paleozoic, well above the pre-Flood/Flood boundary. Uniformitarian geologists interpret all these diamictites as glaciogenic, although they are better interpreted as large submarine mass flows (Oard, 1997). Therefore, the

mere presence of diamictite is not diagnostic. The pre-Flood/Flood boundary could undoubtedly be well below the lowest diamictite, which would place the boundary into the Archean in areas where lower Proterozoic “tillites” are located. This all assumes the reliability of the chronostratigraphic aspects of the geologic column.

Table I presents a proposed modification of the Austin and Wise (1994) discontinuity criteria that makes them better suited to help determine the pre-Flood/Flood boundary. Based on these revised criteria, we would favor the placement of the boundary near or at the contact between the igneous and metamorphic basement rocks and the overlying sedimentary rocks, whether Precambrian or Phanerozoic. These criteria may also be relevant for areas outside the southwest United States, but we recommend careful local studies rather than the careless application of these criteria. Note that this boundary negates our earlier assumption (used for sake of argument) that there were thick sedimentary rocks formed on Day 3. It is possible that most, if not all, Precambrian sedimentary rocks were deposited in the Flood.

Conclusion

Application of the revised five discontinuity criteria to selected sites in the southwestern United States suggests that the pre-Flood/Flood boundary is located lower in section than some creationists have suggested, perhaps as low as the contact between sedimentary/metasedimentary strata and underlying igneous/metamorphic basement rocks. It is also possible that some of the basement may have melted (i.e., anatexis) and recrystallized during the Flood. Additionally, the placement of the boundary at this contact, although tentative and open to further research, suggests that there may not be any Day 3 sedimentary rocks in Grand Canyon or the eastern Mojave

Table I. Pre-Flood/Flood boundary criteria and proposed boundary location.

Boundary Criterion	Boundary Location
Paleontological Discontinuity	Between rocks with no fossils and unicellular fossils, but nevertheless equivocal
Erosional Discontinuity	The lowest unconformity or nonconformity at the contact with crystalline basement
Time Discontinuity	Equivocal, but probably lowest discontinuity
Sedimentary Discontinuity	Between igneous/metamorphic basement and sedimentary rocks. Can include some melted basement or possibly even metasedimentary strata
Tectonic Discontinuity	At the lowest discontinuity

Table II. Nine reasons why fossil stromatolites may be inorganic.

1) Definition problems
2) Unsupported bias toward biological origin
3) Not rare in Phanerozoic rocks considered from the Flood
4) Unlike stromatolites from Bermuda and western Australia
5) Very little organic matter or organic structures
6) Practically always consist of carbonate laminations
7) Exist in extensive layers in fossil record unlike local occurrences today
8) There are chemical mechanisms for abiotic formation
9) Huge volume of Precambrian sedimentary rocks not likely between Day 3 and Flood

Desert and that most, if not all, Precambrian sedimentary rocks were laid down in the Flood. The inclusion of thick sections of Precambrian rock as Flood strata may also have interesting consequences for the chronostratigraphic validity of the uniformitarian geologic column.

Appendix 1. Stromatolites and the Pre-Flood/Flood Boundary

There are at least nine reasons (Table II) why creationists should be cautious in accepting stromatolites as biogenic

and thus diagnostic of pre-Flood sedimentation.

(1) It is difficult to unambiguously identify stromatolites (Riding, 2000; Schopf, 2006), especially since some non-biogenetic structures look like stromatolites (Schopf, 2006). Awramik (2006, p. 700) stated:

Confidence in the interpretation of stromatolites as biogenic structures was dealt a serious blow with the proposal that stromatolite structure could theoretically result from abiotic processes in sediment accumulation. To make matters more bewildering, the very definition of stromatolite is contentious.

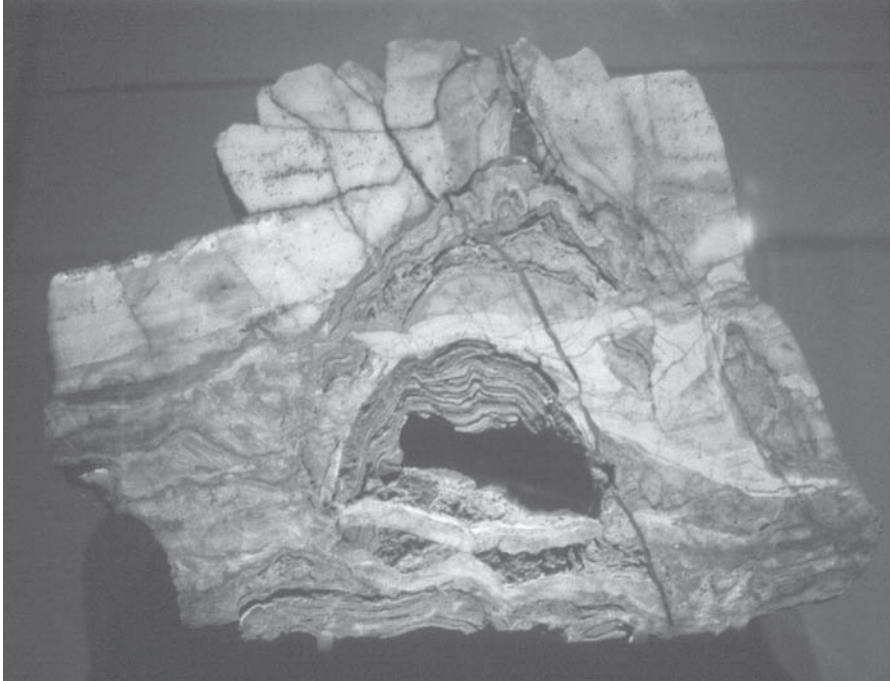


Figure 5. A fossilized stromatolite collected from Western Australia and purported to be one of the oldest evidences of life on Earth at 3.5 billion years old. On exhibit at the National Museum of Natural History (Smithsonian). Approximately 30 cm in height.

Some researchers simply define stromatolites as biological structures, while others prefer a more descriptive definition (clearly a more scientific approach). Most think of stromatolites as upside down dish-like structures (Figure 5). However, modern research has shown that there are a number of stromatolite-like laminations, and the variety has caused confusion in terminology and cast doubt on any biogenic origin. For instance, some horizontal laminations are interpreted as microbial mats, which are then defined as stromatolites.

So what is a stromatolite? Since the present is supposed to be the key to the past, biologists have studied a complex variety of microbial mats and stromatolites in various fresh and saltwater environments (Riding, 2000; Visscher and Stolz, 2005). These are then extrapolated to the rock record. For the sake of simplicity, we will assume that the typical inverted, stacked dish structures

are the stromatolites under discussion in regard to the pre-Flood/Flood boundary (Figure 5).

(2) Researchers have been *biased* toward the biogenic interpretation of these fossil structures.

But in the past, we have tended to rely too much upon evidence that is ‘consistent with’ microbial processes, without falsifying or rejecting (*sensu* Popper 1959) other possible non-biological scenarios that may likewise be consistent. We have tended to ask ‘what do these structures remind us of’ rather than ‘what are these structures?’ (Brasier et al., 2006, p. 889).

This bias has steered paleontologists away from abiotic mechanisms, stifling research.

(3) These structures are found in strata that were clearly deposited by the Flood. Although stromatolites are best known in Precambrian strata between 2.8 and 1.0 billion years (Flügel, 2004),

and even as far back as 3.4 billion years in Western Australia (Allwood et al., 2006; Awramik, 2006), they are also present in Phanerozoic strata (Bertrand-Sarfati and Monty, 1994; Flügel, 2004; Gebelein, 1969; Monty, 1981; Riding, 2000). (Some uniformitarians dispute the biogenic origin of the very oldest features [Brasier et al., 2006; Lowe, 1994].) Most creationists would consider most Phanerozoic sedimentary rocks as Flood deposits. Thus, a Flood mechanism for the development of “stromatolites” is required unless they are all pre-Flood structures that were transported and redeposited intact. In that case, the most likely mechanism would be abiogenic, since the Flood year does not provide sufficient time for slowly accumulating stacked microbial mats. And if Flood stromatolites might be inorganic, then why not “older” stromatolites?

(4) Fossil stromatolites are typically *unlike* modern examples observed in such classical environments as Bermuda and Shark Bay, Western Australia (Ginsburg, 1991). The stromatolites in Shark Bay show coarse rock particles and crude banding and are isolated mounds (Pope et al., 2000; Riding, 2000; see Figure 6). “Ancient” stromatolites are commonly evenly layered, fine-grained laminations and are interconnected. All of these features are dissimilar from today’s upside down, stacked-dish stromatolites. Hence, there really is no clear modern analog for fossil stromatolites, and the uniformitarian principle fails yet again! Riding (2000, p. 204) summarized: “If this is correct, the question arises whether and where modern analogues for Precambrian stromatolites actually exist.”

(5) There is very little organic matter or organic structures found in fossil stromatolites (Grotzinger and Rothman, 1996; Hofmann, 1969; Riding, 2000; Schopf, 2006; Seong-Joo et al., 1999). Awramik (2006, p. 700) admitted,

Only rarely are microfossils found in ancient examples, but many researchers consider stromatolites to



Figure 6. Stromatolites from Shark Bay, Western Australia, showing the coarse particles and crude banding of the isolated mounds (display from the Museum of the Rockies, Bozeman, Montana). The layers are formed as cyanobacteria emit slime, which captures rock particles. As the particles create a layer, the colony secretes more slime and other layers form, eventually creating the stromatolite.

be the products of microbe-sediment interaction, and so to be fossils.

The organic matter and structures that are sometimes claimed are equivocal and can occur by chance. Schopf (2006, p. 873) stated,

Unfortunately, even this criterion [preserved microfossils or trace fossils] falls short, since the mere presence of fossilized micro-organisms within an ancient stromatolite-like structure cannot demonstrate that the structure accreted as a direct result of microbial mat-building activities.

This criterion is doubtful too, because of the presence of Precambrian carbonaceous matter and microfossils (Snelling, 1991; Tice and Lowe, 2006). Brasier et al. (2006, p. 888) stated, "Carbonaceous matter is found remarkably widely across Archaean cratons." Carbon isotope ratios indicate that this carbon is biogenic, but abiotic processes can

also produce carbon ratios that appear biogenic (Brasier et al., 2006; Tice and Lowe, 2006). If organic matter and microfossils, even the more complex eukaryotes (Oard, 2001), are preserved in the rocks, then why would organic matter be almost nonexistent in stromatolites if they really were formed biologically? Although the rarity of organic matter and structures directly associated with stromatolites could be caused by diagenesis, it could also indicate an abiogenic origin.

(6) Practically all fossil stromatolites occur in carbonates (Schieber, 1998). Schopf (2006) stated, "Almost all known ancient stromatolites are or were originally of calcareous composition" (p. 873). But modern stromatolites are found in a variety of sedimentary environments and bind all types of sediments (Schieber, 1998). Those in Grand Canyon are associated with carbonates, even

those in the Kwagunt Formation used to place the pre-Flood/Flood boundary at the base of the Sixtymile Formation (Austin and Wise, 1994). Given the complexity of carbonate depositional and diagenetic processes, it is certainly possible that stromatolites may be an artifact of inorganic carbonate processes.

(7) Fossil stromatolites can be widespread over tens of kilometers while those today are found over a much smaller area (Ginsburg, 1991).

(8) Non-biological mechanisms have been shown to produce structures very similar to stromatolites (Brasier et al., 2006; Perri and Tucker, 2007; Pope et al., 2000).

But when computer models suggested that simple chemical reactions and physical forces can mimic stromatolites, those fossils too were cast in doubt. Martin Brasier of Oxford University is less sanguine, arguing that the structures [presumed stromatolites from 3.4 billion-year rocks from Western Australia] are more likely chemical precipitates. He also objects to the reasoning in the *Nature* paper. "You can't use the argument that complexity is the signature for life," he says. "The extreme variability is what we would expect from a physical mechanism" (Stokstad, 2006, p. 1,457).

As a result, some evolutionists have expressed doubt over the biological origin of at least some of the stromatolites found in the sedimentary rocks (Brasier et al., 2006; Grotzinger and Rothman, 1996; Hoffman, 1973; Lowe, 1994; Schieber, 1998; Stokstad, 2006; Walter, 1996). Perri and Tucker (2007, p. 207) admitted, "Proving a biogenic microbial origin for ancient stromatolites can be very difficult." Brasier et al., (2006, p. 894) stated,

We agree with Schopf (2006), that "it is perhaps impossible 'to prove beyond question' that the vast majority of reported stromatolites...are assuredly biogenic."

(9) Precambrian sedimentary and metasedimentary strata occur in great thicknesses in the western United States, as well as many other areas of the world. These strata are 4 km thick in the eastern Grand Canyon and 6 km thick in the eastern Mohave Desert. The Precambrian Belt Supergroup in western Montana is up to 20 km thick and covers an area over 200,000 km² (Horodyski, 1993; Ross and Villeneuve, 2003). Furthermore, the Belt metasedimentary rocks show fairly uniform grain sizes of coarse silt and fine sand over a wide area, and there is very little tectonic movement indicated by the strata. Uniformitarian scientists must accept that Belt sediments were deposited in stable, shallow-water environments that somehow produced 20 km of strata *before* uplift and tilting.

It is unlikely that such thick, widespread Precambrian strata could accumulate in the pre-Flood world. They are too thick, often too widespread, and show little if any erosion between layers (like Phanerozoic sedimentary rocks). These all imply large-scale erosional/depositional processes acting in conjunction with large-scale tectonic movements. It seems more reasonable to associate those processes with significant catastrophism. That means that these thick Precambrian sediments are either relicts of Day 3 or the Flood. In either case, stromatolites would not have formed by uniformitarian mechanisms. The inorganic origin of stromatolites is an area ripe for diluvial research.

If the stromatolites below the proposed pre-Flood/Flood boundary are inorganic, then there probably is no paleontological discontinuity at the base of the Sixtymile Formation. Wise and Snelling (2005) astutely left open the possibility that the stromatolites are inorganic. However, they also believe that it would make no difference to their proposed boundary, because a non-biological origin would still require the passage of sufficient time to rule out the

Flood, making the structures pre-Flood. But that requires a leap of faith; if these stromatolites are inorganic, only further research can determine the timing of their formation.

Appendix 2. Rates of Lithification

Wise and Snelling (2005) assumed the pre-Flood strata would have more time



Figure 7. Red Conglomerate Peaks along the Montana/Idaho border about 25 miles west of Interstate 15 (mountain just right of center in background). Peaks consist of erosional remnants of a thick sheet of breccia.



Figure 8. Rounded and angular clasts from breccia of the Red Conglomerate Peaks. Most clasts are limestone with fossils, but some are sandstone. These clasts are eroded Flood rocks with the clasts in the breccia dated as Paleozoic within the geological column.

to lithify, while Flood strata would not have enough time to harden completely until after the Flood. But they presented no evidence to support these assumptions. There has been little if any published creationist research on this subject, and quantifying lithification rates in the numerous physical and chemical environments of the Flood is a massive problem. However, there are several points worth making at present.

Wise and Snelling (2005) assumed time was the major factor in lithification. But it is only one factor. Sediments are converted into sedimentary rock by a combination of compaction and precipitation of cement around sediment grains (Plummer and McGeary, 1996), but there are many other variables (Bjørlykke and Egeberg, 1993; Haddad et al., 2006; McBride, 1989; Molenaar et al., 2007; Pettijohn et al., 1987). In order for the cement to work its way into the sediments, great volumes of fluids must readily flow through the pore spaces, but as more and more cement is deposited the porosity drops substantially. Cements include calcite, silica, iron oxides, and various clay minerals. To further complicate the problem, framework grains can dissolve and be redeposited as interstitial cement, depending on the chemical environment. Diagenesis is complex and greatly complicates the rock history. Because Flood processes may well have been unique, we do not understand diagenetic processes in Flood sediments. Thus we have no way of knowing how quickly they might or might not lithify.

There are many indirect evidences for rapid lithification during the Flood. Breccias in southwest Montana and adjacent Idaho that were indisputably produced in the Flood (Figures 7 and 8) must have lithified rapidly, since both sandstone and carbonate clasts within the breccia were rock prior to their erosion and subsequent redeposition by late Flood catastrophic processes (Oard et al., 2005).

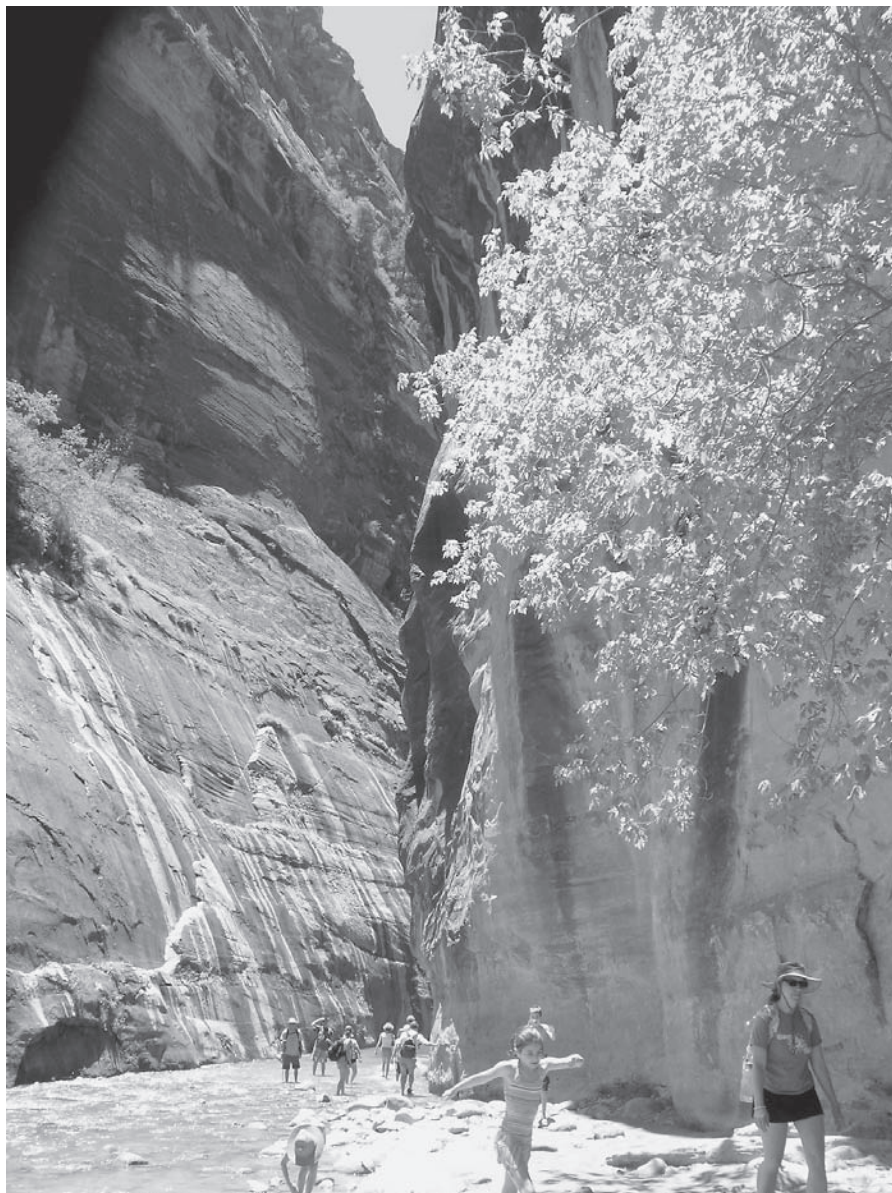


Figure 9. The Narrows, a 600-meter-deep slot canyon at the upper end of Zion Canyon, Zion National Park.

Another evidence of rapid lithification is the vertical cliffs of cross-bedded sandstone at such places as Zion National Park. These cliffs are over 600 m high (Figure 9) and were hard prior to erosion. The same can be said of any other deep, vertically-walled canyon carved into sedimentary rocks, such as the Grand Canyon. Since the scale of erosion implies late Flood runoff (Walker, 1994), lithification must have occurred between deposition and

canyon cutting—at most a matter of months.

Another example of Flood-lithified sediments is their erosion into planation surfaces, and these are ubiquitous (Figures 10 and 11). Since they most likely formed late in the Flood, the underlying sediments must have been already lithified (Oard, 2004; 2007; 2008). Pediments are planation surfaces at the foot of mountains or a ridge. Such surfaces are often cut across granite and



Figure 10. Flat-topped granitic mountains, northwest Wind River Mountains, Wyoming.



Figure 11. Flat-topped Gypsum Mountain, northwest Wind River Mountains, Wyoming. This mountain is composed of limestone dipping about 40° to the west (right). Gypsum Mountain is located just west of the granitic mountains shown in figure 10, indicating planation sheared both igneous and sedimentary rocks in the Wind River Mountains.

tilted layers of sandstone and shale of all uniformitarian ages (Figures 12 and 13). The fact that most planation surfaces and pediments are capped by rounded rocks is further evidence for late Flood erosion.

These surfaces would appear much different if the rocks below had been soft sediment or molten granite when they were eroded. Like rapidly formed Flood clasts and canyons carved into hard sedi-

mentary rock, these planation surfaces and pediments are evidence for the development of lithified sediments during the Flood. If it must be possible that lithification can occur rapidly, then only empirical field research can determine which rocks lithified at what time.

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Figure 12. Pediment in the Ruby Valley along the western slope of the Gravelly Range, Southwest Montana. Note that the valley-fill sedimentary rocks dip right (east), while the surface of the pediment dips left (west) and truncates the sedimentary layers evenly at a low angle.



Figure 13. Coarse gravel veneer capping the pediment shown in Figure 12. Note that the clasts are rounded to subrounded, indicating that water truncated the pediment.

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A Realistic Simulation Model for Uranium Series Geochronological Dating

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Abstract

This paper presents a simulation model for uranium series geochronological dating employed in adjusting the age of the earth claimed by evolutionary scientists. The model assumes that decay half-lives have been constant throughout earth history, but introduces detailed equations to simulate diffusion and migration of radionuclide through a porous medium. Theoretically, a radiometric-dating model should be developed based on the solute transport theory, which involves tedious numerical computation. However, the traditional model imposes two crude assumptions to simplify the computational processes, even though it is known that inevitable errors may result. They are: (1) mineral deposits are confined in a closed system and no radionuclide migration can take place, and (2) the decay chain is in its “ultimate” equilibrium at the time of dating. On the other hand, the proposed simulation model calculates the age of minerals based on the solute transport theory. As such, the errors inherited in the traditional model can be minimized or avoided. The results of model verification indicate that there are excellent agreements between the simulation results and the analytical solutions for two cases: radioactive decay and diffusion. Comparison of the results indicates that the closed system assumption results in overestimation of the age of mineral when the age exceeds the “critical year.” A comparison of an existing study for a rhyolite from the Cobb Mountain, California and results from the simulation model also show the same trend.

Introduction

The dispute about the age of earth between evolutionary scientists and biblical creationary scientists has continued for centuries. Evolutionists now claim an age of 4.5 billion years for the age of the earth, whereas biblical creationists claim an age of no more than 8,000 years. In spite of recent progress, I do not see that a satisfactory solution has been proposed to reconcile this dispute. Since the radiometric dating method is the most important means of determining the age of the earth by scientists, it is important to evaluate the accuracy of this dating method.

A preliminary investigation revealed that a radiometric-dating model should be developed based on solute transport theory, which involves tedious numerical process. The solute transport theory depicts the relationships between the rate of transport of embed radioactive nuclei (radionuclides) in a porous medium and the characteristics of the medium and radionuclides. The medium is assumed to have a finite ability to conduct the solute transport in a fluid solvent via fluid flow, which can diffuse and migrate. This is modeled using *solute transport system equations*. The traditional model imposed two crude assumptions to simplify the computational processes, knowing inevitable errors may result. They are (1) the radionuclides in the mineral deposit are confined in a closed compartment and no radionuclide migration can take place (closed-system assumption), and (2) the radioactive decay series is in its ultimate equilibrium stage at the time

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of dating (ultimate-equilibrium assumption) (e.g., Nier et al., 1941; Wetherill, 1956; Tera and Wasserburg, 1972; Compston et al., 1985; Durrance, 1986, p. 287; Getty and DePaolo, 1995; Neymark et al., 2000; Pike et al., 2002; Tera, 2003; Mundil et al., 2004; Chang et al., 2006; van Calsteren and Thomas, 2006).

An ultimate-equilibrium stage is defined as a stage when the ingrowth of the stable radionuclide in a decay chain reaches to the same decay rate of its parent nuclide. In reality, a ^{238}U radionuclide decays into ^{234}U , ^{230}Th , ^{226}Ra , and finally to ^{206}Pb (taking into account only the long half-life radionuclides). In the beginning, the rate of ingrowth of ^{206}Pb will be much smaller than the decay rate of ^{238}U . However, the discrepancies between these two rates become smaller and smaller with the increase in the duration of decay, and eventually reaches zero or ultimate equilibrium.

Because the ratio of the stable daughter nuclide to the remaining parent nuclide is used to measure the age of minerals, ignoring the migration loss of both parent and daughter nuclides and the distorted ultimate-equilibrium assumption could potentially create significant error in dating. This potential error has been pointed out by numerous investigators (e.g., Szabo and Rosholt, 1969; Hille, 1979; Durrance, 1986, p. 306; Pike et al., 2002; Tera, 2003; van Calsteren and Thomas, 2006). Nevertheless, the dating methods using these crude assumptions continue to dominate the field of geochronology.

To improve the accuracy of radiometric dating, a simulation model that considers the migration of radionuclide and transient radionuclide decay is needed to simulate the dynamics of the radiometric-dating system. With the advanced computer modeling techniques available today, employing a dynamic simulation model for radiometric dating is now realistically possible.

This paper presents the performance of the simulation model employed in adjusting the age of earth claimed by scientists. The model is designed to transport the parent and daughter nuclides from the crystallized mineral deposit to the ambient crystalline rock in a three dimensional (3-D) system. The transport processes include convective and dispersive transport and molecular diffusion, as well as transient radioactive decay processes. A ^{238}U - ^{206}Pb series method is selected because this method is one of the most important methods used in determining the age of the earth. Model verification on the decay and diffusion processes is also conducted for checking the credibility of the model.

Theoretical Background of Dating Model

Generic Mass-Transport System Equation

The basic equations governing a mass-transport system were well established by previous investigators (e.g., Duguid and Reeves, 1976; Pinder and Gray, 1977; Huyakorn et al., 1986;

McDonald and Harbaugh, 1988; Anderson and Woessner, 1992; Hydrogeologic, Inc., 1995; Leake and Lilly, 1997; Yeh et al., 2002; and Hung, 1986, 2000, and 2004). Although the basic form of the system equations derived by each investigator vary slightly, the generic form can be summarized as follows.

Flow System Equation: The generic flow system equations for a steady flow in a heterogeneous, anisotropic, and variably saturated porous medium can be summarized in a Cartesian coordinate system as:

$$v_i = -K_i k_{rw} \frac{\partial h}{\partial x_i} \quad (1)$$

(for $i = 1$ to 3)

for the equation of motion and

$$\sum_{i=1}^3 \frac{\partial}{\partial x_i} \left(K_i k_{rw} \frac{\partial h}{\partial x_i} \right) = 0 \quad (2)$$

for the continuity equation (Bear, 1979). In the above equations, v_i are the components of Darcy velocity, K_i are the components of saturated hydraulic conductivity, k_{rw} is the relative conductivity, h is the hydraulic head, and x_i are the spatial coordinates.

Equation (1) expresses the postulated assumption that fluid will migrate away from regions of high hydraulic pressure (head) h and toward regions of low hydraulic pressure h . Equation (2) expresses the continuity condition, which basically states that fluid is not created or destroyed but may migrate across boundaries.

Solute Transport System Equation: The generic solute transport system equation for the k th radionuclide in a ℓ member decay chain can be summarized as (Bear, 1979):

$$\begin{aligned} \frac{\partial}{\partial x_i} \left(D_{ij} \frac{\partial c_k}{\partial x_j} \right) - v_i \frac{\partial c_k}{\partial x_i} &= \phi S_w R_k \frac{\partial c_k}{\partial t} \\ &+ \phi S_w R_k \left(\lambda_k c_k - \frac{A_k R_{k-1}}{A_{k-1} R_k} \lambda_{k-1} c_{k-1} \right) \end{aligned} \quad (3)$$

(for $i = 1$ to 3 , $j = 1$ to 3 , and $k = 1$ to ℓ when $k-1 > 0$)

where D_{ij} is the component of apparent hydrodynamic dispersion tensor, c_k is the concentration of the k th daughter nuclide in the ℓ member decay chain desorbed in the water; v_i is the Darcy velocity; Φ is the effective porosity, S_w is the degree of water saturation, R is the retardation factor, λ is the radionuclide decay constant, A is the atomic weight, and subscripts

k, i and j represent the order of daughter nuclide in the decay series and spatial coordinates x, y and z. Here the Einstein summation convention is followed, that the repeated indices i and j are summed over from 1 to 3.

Traditional Model

The processes of solving the above dynamic equations are extremely complex, involving long and intricate mathematical analyses. To avoid these complex processes, the traditional model simplifies them by imposing two crude assumptions: closed-system and ultimate-equilibrium assumptions.

The first assumption eliminates the necessity of the flow equations—Equations (1) and (2)—and the transport terms in the solute transport equation. As a result, the governing system equations are simplified into the form:

$$\frac{\partial c_k}{\partial t} + \left(\lambda_k c_k - \frac{A_k}{A_{k-1}} \lambda_{k-1} c_{k-1} \right) = 0 \quad (4)$$

(for k = 1 to ℓ when k-1 > 0)

Despite the fact that an analytical solution can be obtained from Equation (4), previous investigators simplified the solution further by imposing the second assumption, which assumed the rate of ingrowth of ^{206}Pb is in equilibrium with the rate of ^{238}U decay loss. That is, it assumes that ^{238}U decays into ^{206}Pb directly. ^{206}Pb is stable and thus has zero decay constant; hence, assuming that the first term in Equation (4) represents the ingrowth of ^{206}Pb for k = 2 (final member of the decay chain), then this rate should be equal to the decay rate of ^{238}U (k-1=1). The solution of this simplified differential equation is shown by Durrance (1986) or Getty and DePaolo (1995) as:

$$^{206}\text{Pb}(t) = ^{206}\text{Pb}(0) + ^{238}\text{U}(t) \cdot [\text{Exp}(\lambda_{238}t) - 1] \quad (5)$$

In Equation (5), λ_{238} represents the decay constant for ^{238}U , t represents the time, and ^{206}Pb and ^{238}U represent the number of atoms for ^{206}Pb and ^{238}U , respectively.

When this assumption is imposed, the age of the mineral can then be calculated from Equation (5) as:

$$t = \frac{1}{\lambda_{238}} \log_e \left[\frac{^{206}\text{Pb}(t)}{^{238}\text{U}(t)} - \frac{^{206}\text{Pb}(0)}{^{238}\text{U}(t)} + 1 \right] \quad (6)$$

That is, the age of the mineral can be calculated from Equation 6 once the $^{206}\text{Pb}/^{238}\text{U}$ ratio of the mineral is measured and its $^{206}\text{Pb}(0)/^{238}\text{U}(t)$ ratio is properly estimated. Equation (6) is the basic equation of the traditional model.

Proposed Dynamic Simulation Model

The proposed simulation model is designed to simulate the transport of radionuclides based on the basic equations described above. Existing models, such as the MODFLOW (MODular FLOW) –SURFACT (integrated with a new efficient Scheme to treat Unconfined, non-ponding Recharge, and Fracture well flow modules for the Analysis of Contaminated Transport) model (Hydrogeologic, Inc., 2001) or GMS (Groundwater Modeling System) model (U.S. Army Waterways Experiment Station, 2002), were designed for comprehensive environmental engineering applications. Therefore, direct application of these models may suffer from difficulties of (1) modeling the intended conceptual model accurately, (2) prolonged duration of analysis, and (3) extracting the required specific output values. Therefore, a new model is needed for exclusive radiometric-dating application.

Conceptual Model

The conceptual model assumes a mineral is deposited at the center of a homogeneous anisotropic host formation in the earth crust and is exposed to the natural geohydrological envi-

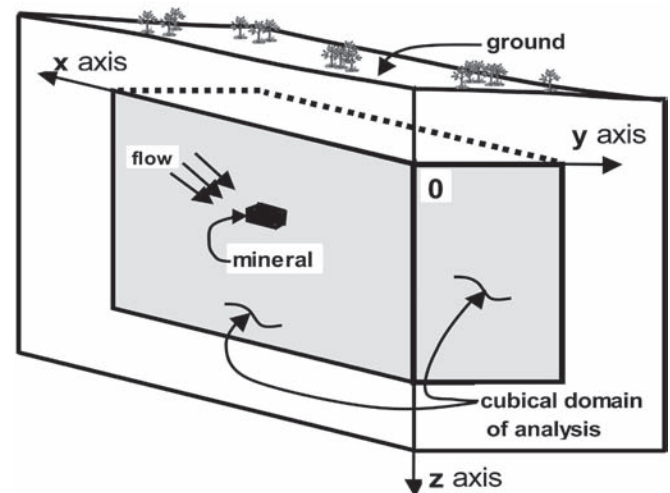


Figure 1. Schematic of the conceptual model for the simulation model. It shows the geohydrological environment after the mineral is deposited in the earth crust as an open system.

ronment, including convective and dispersive transports from the ambient groundwater flow. Figure 1 shows the schematic of this conceptual model.

Flow-System Equation

The mineral and its ambient host rock selected for radiometric dating are normally crystallized and nonporous in texture and underlain below the ground surface. Therefore, the transport media, including mineral and host rock, would have very low percentage of gravity water porosity (Hillel, 1980; Hung, 1983 and 2005). It follows that the transport media is constantly saturated with pellicular water (*pellicular water* is the moisture content in the porous media that cannot be lost by gravity drainage process but by natural drought process) even under unsaturated flow conditions. Thus, the hydraulic conductivity of the mineral and the host rock will always exhibit their near-saturated hydraulic conductivity, respectively (Hillel, 1980; Hung, 1983 and 2005).

Therefore, the basic flow-system equations to be used in the simulation model, Equations (1) and (2), can be simplified and expanded as:

$$\begin{aligned} v_x &= -K_x \frac{\partial h}{\partial x} \\ v_y &= -K_y \frac{\partial h}{\partial y} \\ v_z &= -K_z \frac{\partial h}{\partial z} \end{aligned} \quad (7)$$

and

$$\frac{\partial}{\partial x} \left(K_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(K_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(K_z \frac{\partial h}{\partial z} \right) = 0 \quad (8)$$

The space-dependent components of the velocity vector can therefore be solved independently. The results of the flow-system analysis can then be applied to the solute-transport-system analysis.

Solute-Transport-System Equation

As discussed above, the relative hydraulic conductivity and the degree of water saturation can be approximated as unity. It follows that Equation (3) can be expanded as:

$$\begin{aligned} & \frac{\partial}{\partial x} \left(D_{xx} \frac{\partial c_k}{\partial x} \right) + \frac{\partial}{\partial x} \left(D_{xy} \frac{\partial c_k}{\partial y} \right) + \frac{\partial}{\partial x} \left(D_{xz} \frac{\partial c_k}{\partial z} \right) \\ & - v_x \frac{\partial c_k}{\partial x} + \frac{\partial}{\partial y} \left(D_{yx} \frac{\partial c_k}{\partial x} \right) + \frac{\partial}{\partial y} \left(D_{yy} \frac{\partial c_k}{\partial y} \right) \\ & + \frac{\partial}{\partial y} \left(D_{yz} \frac{\partial c_k}{\partial z} \right) - v_y \frac{\partial c_k}{\partial y} + \frac{\partial}{\partial z} \left(D_{zx} \frac{\partial c_k}{\partial x} \right) \\ & + \frac{\partial}{\partial z} \left(D_{zy} \frac{\partial c_k}{\partial y} \right) + \frac{\partial}{\partial z} \left(D_{zz} \frac{\partial c_k}{\partial z} \right) - v_z \frac{\partial c_k}{\partial z} \\ & = \phi S_w R_k \frac{\partial c_k}{\partial t} + \phi S_w R_k \left(\lambda_k c_k - \frac{A_k R_{k-1}}{A_{k-1} R_k} \lambda_{k-1} c_{k-1} \right) \end{aligned} \quad (9)$$

In Equation (9), c_k is the concentration of the k th decay member radionuclide. The components of the apparent hydrodynamic dispersion tensor, D_{xx} , D_{xy} , D_{xz} , D_{yx} , D_{yy} , D_{yz} , D_{zy} , and D_{zz} are space dependent and given by Scheidegger (1961), and Burnett and Frind (1987), for stratified porous media as:

$$\begin{aligned} D_{xx} &= \alpha_{Lh} \frac{v_x^2}{|v|} + \alpha_{Th} \frac{v_y^2}{|v|} + \alpha_{Tv} \frac{v_z^2}{|v|} + \beta D_0 \\ D_{yy} &= \alpha_{Th} \frac{v_x^2}{|v|} + \alpha_{Lh} \frac{v_y^2}{|v|} + \alpha_{Tv} \frac{v_z^2}{|v|} + \beta D_0 \\ D_{zz} &= \alpha_{Tv} \frac{v_x^2}{|v|} + \alpha_{Tv} \frac{v_y^2}{|v|} + \alpha_{Lv} \frac{v_z^2}{|v|} + \beta D_0 \\ D_{xy} &= D_{yx} = (\alpha_{Lh} - \alpha_{Th}) \frac{v_x v_y}{|v|} \\ D_{xz} &= D_{zx} = \left(\frac{\alpha_{Lh} + \alpha_{Lv}}{2} - \alpha_{Tv} \right) \frac{v_x v_z}{|v|} \\ D_{yz} &= D_{zy} = \left(\frac{\alpha_{Lh} + \alpha_{Lv}}{2} - \alpha_{Tv} \right) \frac{v_y v_z}{|v|} \end{aligned} \quad (10)$$

where α is the dispersivity, β is the tortuosity, D_0 is the free-water molecular diffusion coefficient, and the subscripts Lh, Th, Lv, and Tv are indices for horizontal longitudinal, horizontal transverse, vertical longitudinal, and vertical transverse direction respectively. *Tortuosity* refers to the ratio of the diffusion

coefficient in the porous medium to the diffusion coefficient D_0 in free space. Usually it is smaller than unity in the medium since the solid particles in the medium impede the flow, or cause a *tortuous path* for the diffusion.

Model Development

Basic Equations

As shown in Equation (9), the time derivative of the radionuclide concentration is a linear sum of the transport effect, and the decay/ingrowth effect. To simplify the modeling processes, these two effects are separated in the model implementation. After the separation, the basic equations are expressed in

$$\begin{aligned} \frac{\partial \hat{c}_k}{\partial t} = \frac{1}{\phi S_w R_k} & \left\{ \frac{\partial}{\partial x} \left(D_{xx} \frac{\partial \hat{c}_k}{\partial x} \right) + \frac{\partial}{\partial x} \left(D_{xy} \frac{\partial \hat{c}_k}{\partial y} \right) \right. \\ & + \frac{\partial}{\partial x} \left(D_{xz} \frac{\partial \hat{c}_k}{\partial z} \right) - v_x \frac{\partial \hat{c}_k}{\partial x} + \frac{\partial}{\partial y} \left(D_{yx} \frac{\partial \hat{c}_k}{\partial x} \right) \\ & + \frac{\partial}{\partial y} \left(D_{yy} \frac{\partial \hat{c}_k}{\partial y} \right) + \frac{\partial}{\partial y} \left(D_{yz} \frac{\partial \hat{c}_k}{\partial z} \right) - v_y \frac{\partial \hat{c}_k}{\partial y} \\ & + \frac{\partial}{\partial z} \left(D_{zx} \frac{\partial \hat{c}_k}{\partial x} \right) + \frac{\partial}{\partial z} \left(D_{zy} \frac{\partial \hat{c}_k}{\partial y} \right) \\ & \left. + \frac{\partial}{\partial z} \left(D_{zz} \frac{\partial \hat{c}_k}{\partial z} \right) - v_z \frac{\partial \hat{c}_k}{\partial z} \right\} \end{aligned} \quad (11)$$

$$\frac{\partial \hat{c}_k}{\partial t} = \left(\frac{A_k R_{k-1}}{A_{k-1} R_k} \lambda_{k-1} c_{k-1} - \lambda_k c_k \right) \quad (12)$$

respectively, representing the transport component and decay/ingrowth component.

A standard central difference scheme is selected for the numerical analysis of the transport component. The computer code for this component is implemented in the main program. More details of the formulation of the model are given in Appendix A.

Model Verification

The computer encoding and model verification can be tested for some limiting cases. Two independent processes are selected: radioactive decay and hydrodynamic transport. The results of verification are detailed as follows.

Radioactive Decay Process

During the course of verifying the radioactive decay process, the portion of simulation for the hydrodynamic transportation is bypassed, so that the source of ^{238}U and its progenies are assumed to remain in the designated compartment as a closed system. For the purpose of model verification, it is assumed that one mole of ^{238}U is placed at the center of the simulation field. We are not necessarily assuming that this is a realistic assumption; we are just using it to test the computer code and the model on which it is based. The simulation is conducted for 10,000,000 years in which the masses of parent and its progenies are integrated. The results of simulation for all five radionuclides in the decay chain, ^{238}U , ^{234}U , ^{230}Th , ^{226}Ra , and ^{206}Pb , are printed out for the target year of 100, 1,000, 10,000, 100,000, 1,000,000, and 10,000,000.

In parallel to the simulation, the decay/ingrowth products from the same one mole of ^{238}U are also calculated utilizing the Bateman equation detailed in Appendix B.

The results of the analysis are plotted together with the results of simulation and presented in Figure 2. The results obtained from the analytical solution and the simulation model agree with each other very well, confirming that the mathematical formulas and the computer codes developed for the decay portion are valid.

Transport Process

Because the simulation model is designed for a very low hydraulic conductivity condition, the entire radionuclide transport process is predominated by the dispersion/diffusion process. Therefore, for the purposes of model verification, the analytical solution representing point source diffusion in an infinite space is selected. As derived by Crank (1975), the analytical solution for a point source at the center of an infinite space takes the form

$$C = \frac{M}{8(\pi Dt)^{3/2}} \text{Exp}\left(-\frac{r^2}{4Dt}\right) \quad (13)$$

where C is the concentration of diffusing substance, M is the source strength, D is the diffusion coefficient, r is the distance from the source, and t is the time elapsed.

By assuming the source strength is 100 grams and the diffusion coefficient is $0.01 \text{ cm}^2/\text{yr}$, the distribution of concentrations around the source point is calculated from Equation (13) for one, two, three, and four years after diffusion has commenced. The results of these calculations are presented in Figure 3.

To verify the simulation model, comparable source strength of 100 grams is placed at the center of the digitized three-dimensional space. The components of the equivalent

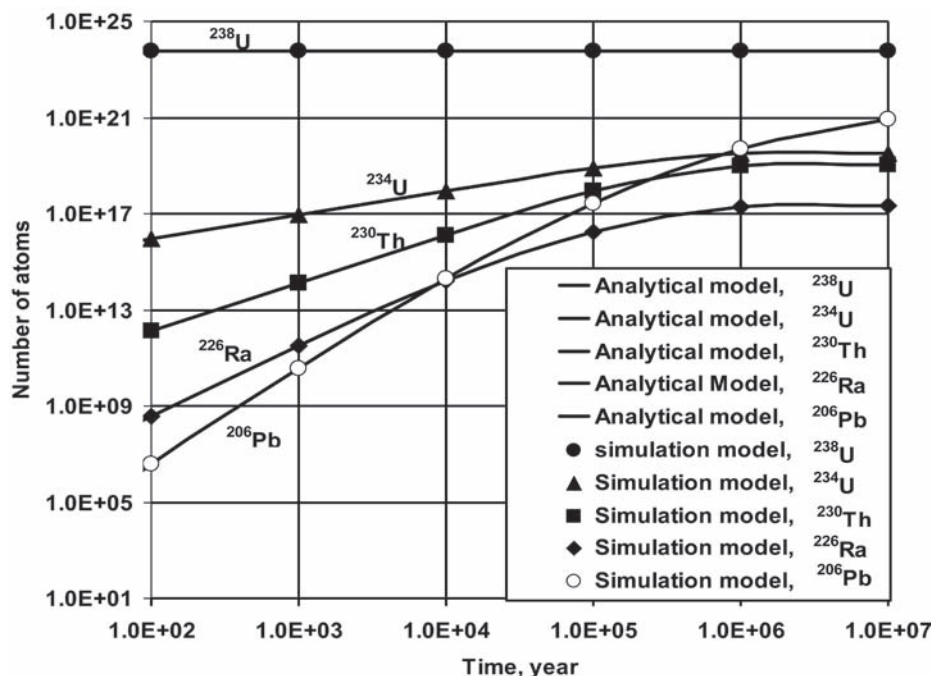


Figure 2. Comparison of the results of radionuclide decay/ingrowth obtained from analytical and dynamic simulation models. The initial ^{238}U strength is assumed to be 1 mole for both calculations. The close match of these two solutions validates the simulation model.

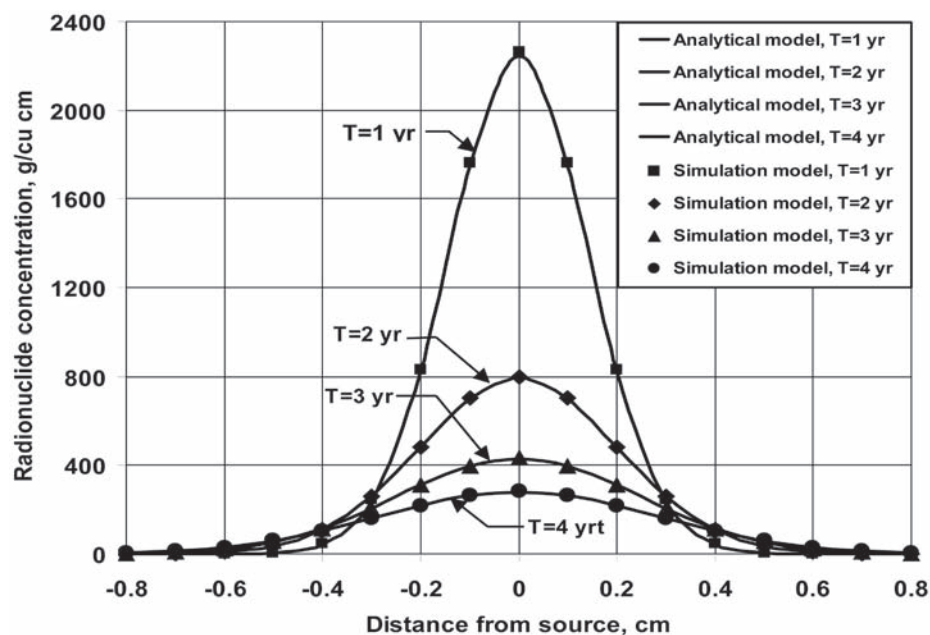


Figure 3. Comparison of the results of radionuclide concentrations obtained from analytical and dynamic simulation models. The source strength and the diffusion coefficient are assumed to be 100 grams and $0.01 \text{ cm}^2/\text{yr}$, respectively. The close match in the concentration distribution between the results of simulation and analytical solutions validates the simulation model.

diffusion coefficients in the x, y, and z directions are maintained at $0.01 \text{ cm}^2/\text{yr}$, and their space increments are maintained at 0.05 cm . The simulation suppresses the radioactive decay and convective transport effects by bypassing the radioactive decay and convective transport processes. The results of concentration simulation are also plotted for one, two, three, and four years after the commencement of diffusion and for the spaces at 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8 cm from the source, respectively, on Figure 3. Figure 3 shows that the concentrations obtained from the simulation model and the analytical model agree each other very well. This also implies that the model equation and numerical algorithm used in the model for dispersion process are accurate and valid.

Because the convective flow portion of the model is a simple addition of numerical scheme to the dispersion process, the transport portion of the simulation is also considered to be accurate. From the results above, one can claim that this simulation model is accurate and valid.

Comparison of Simulation and Traditional Models

Scenario of Analyses

For the simulation model, it is assumed that one unit mass of pure ^{238}U is deposited at the center of the domain of analysis. During the process of simulation, the model calculates the variation of the mass of each radionuclide in the decay chain and the $^{206}\text{Pb}/^{238}\text{U}$ ratio with time. As to the traditional model, the time variation of the $^{206}\text{Pb}/^{238}\text{U}$ ratios is calculated through Equation (6) by assuming there is no initial mass of ^{206}Pb , which matches with simulation model analysis.

Table I. Collected porosity and density of rocks and mineral from the work of Ho et al. (1989).

Transport media	Porosity, unit-less	Density, g/cm ³
granite	0.03*	2.67*
basalt	0.03	2.67
mineral	0.01	2.65

Note: * denotes the value used for the ambient host rock.

Input Data Collection

The key to generate accurate results from a dynamic simulation is to use the most accurate input parameters. Fortunately, existing studies provide enough valid data for this generic site study. To execute the simulation model, the following input parameters are needed: porosity, density, hydraulic conductivity, dispersivity, free-water molecular diffusion coefficient, distribution coefficient, and radionuclide decay-constant. The collected decay constant for ²³⁸U is also used for the traditional model.

Porosity and Density: Extensive porosity and density data for various igneous and sedimentary rocks have been compiled based on the site-specific field data collected by various investigators (Ho et al., 1989). More than 60 sites for sandstone and nearly 20 sites for granite have been compiled. Nevertheless, for the purposes of this study, conservative values are selected for the model input (Table I.)

Hydraulic Conductivity and Dispersivity: The hydraulic conductivity and dispersivity data have been studied and collected by Ho et al. (1989). Together, 11 sites of granite, 6 sites of basalt, and 65 sites of sandstone hydraulic conductivity data, along with 8 sites of basalt and sedimentary rock for dispersivity were collected. Based on these field and laboratory

data, the conservative values of the hydraulic conductivity and dispersivity are determined for use in this simulation study (Table II.)

Free-Water Molecular Diffusion Coefficient: The free-water molecular diffusion coefficients for various chemical species in water have been collected by Bird et al. (1960) and Thibodeaux (1979). The collected data varies with chemical species and range from 0.2×10^{-5} to 2.0×10^{-5} cm²/sec. Considering only low concentration chemical species and low temperature applications, the most conservative value (the lowest diffusion coefficient), 0.2×10^{-5} cm²/sec (63.1 cm²/yr), is selected for chemical species considered in this study

Distribution Coefficient: Extensive distribution coefficient studies have been conducted for a wide range of radioactive chemical species based on actual laboratory and in-situ measurements (USEPA, 1999a). Although the distribution coefficients may vary widely with the chemical environment, the site-specific data collected in conjunction with the risk assessment of radioactive waste disposal sites (USDOE, 1992; SNL, 1996; USEPA, 1999b) are most suitable for this study. This is because the collected data were all measured under natural groundwater flow environment, which matches with the environment expected in this study.

Because of the non-site-specific nature of this study, the most conservative coefficients (highest values being collected for the above three sites) are selected for the host rock and an additional 20 % is added for the mineral deposit. The selected distribution coefficients for the host rock and mineral deposit are summarized and shown in Table III.

Radioactive Decay Constant: The radioactive decay constants for the known radionuclides are thoroughly investigated and compiled in various radiological handbooks. Normally, the characteristics of radionuclide decay constants are compiled in half-life, from which the radioactive decay constant can be calculated. The half-life of the radionuclides are collected to be 4.468E+9, 2.445E+5, 7.7E+4, 1.6E+3 years for

Table II. Collected hydraulic conductivities and dispersivities from the work of Ho et al. (1989).

Transport media	Hydraulic conductivity, cm/sec		Dispersivity, m		
	Horizontal	Vertical	Longitudinal	Lateral	Vertical
granite	4.0E-9*	2.0E-9*	0.1 *	0.05*	0.05*
basalt	4.0E-9	2.0E-9	0.1	0.05	0.05
mineral	4.0E-10	2.0E-9	0.1	0.05	0.05

Note: * denotes the value used for the ambient host rock.

Table III. Collected distribution coefficients (k_d). They are characterized by the chemical species instead of radionuclide and are collected from the work of government agencies and national laboratories (USDOE, 1992; SNL, 1996; USEPA, 1999b).

Nuclide	Host rock (ml/g)	Mineral deposit (ml/g)
uranium (U)	50	60
thorium (Th)	3200	3840
radium (Ra)	700	840
lead (Pb)	270	324

^{238}U , ^{234}U , ^{230}Th , ^{226}Ra and stable for ^{206}Pb , respectively (US Department of Health, Education, and Welfare, 1970; Shleien et al., 1998).

Results and Discussion

The results of $^{206}\text{Pb}/^{238}\text{U}$ ratio analyses for the traditional model and simulation model are plotted and presented in Figure 4. A comparison of the results indicates that both the simulation model and the traditional model exhibit the same $^{206}\text{Pb}/^{238}\text{U}$ ratio at near 42,000 years. For the purpose of this study, this year is defined as the “critical year or age.” Figure 4 also indicates that the traditional model underestimates the age of the mineral before the age reaching the critical year. Conversely, it overestimates the age after the age exceeds the critical year.

One should notice that the variation of the discrepancies between the traditional model and simulation model are caused by the combined effects of ultimate-equilibrium assumption and closed-system assumption. The underestimate of the age by the traditional model, when the age is younger than the critical age, is due to the predominated effect from the ultimate-equilibrium assumption. Conversely, the overestimate of the age, when the age of the mineral exceeds the critical age, is due to the predominated effect from closed-system assumption. Thus, the intersection of the two curves at the

critical year signifies the time when the two effects compensate each other.

A sub-scenario of unsaturated groundwater-flow conditions is also analyzed and added to Figure 4 to see the effects of unsaturated groundwater-flow conditions. The same figure indicates that there are only minor effects from unsaturated conditions. This is because there are very limited gravity water voids in the host rock and mineral, which are always saturated with pellicular water even under unsaturated condition (Hillel, 1980; Hung, 1983 and 2005).

Comparison with Existing Study

A relatively recent study has been reported by Getty and DePaolo (1995) for dating a rhyolite from the Cobb Mountain volcanic field located 100 km north of San Francisco, California. The study used the measured $^{238}\text{U}/^{207}\text{Pb}$ ratio and $^{206}\text{Pb}/^{207}\text{Pb}$ ratio data for albite, sanidine, matrix (surrounding fill rock), and ilmenite to plot the variation line on the $^{206}\text{Pb}/^{207}\text{Pb}$ ratio vs. $^{238}\text{U}/^{207}\text{Pb}$ ratio plan. Using the measured slope of the $^{206}\text{Pb}/^{207}\text{Pb}$ vs. $^{238}\text{U}/^{207}\text{Pb}$ variation line of 0.00016 (equivalent to $^{206}\text{Pb}/^{238}\text{U}$ ratio), the age of the rhyolite was calculated to be 1.03 million years ago (Ma). Applying the same $^{206}\text{Pb}/^{238}\text{U}$ ratio of 0.00016 to the traditional model and simulation model resulted in 1.05 Ma for the traditional model and 0.0735 Ma for the simulation model. These results together with that

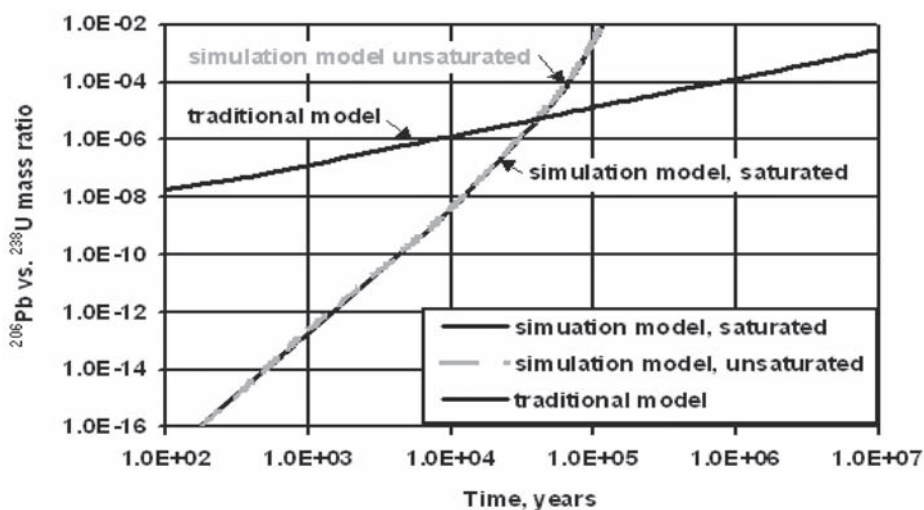


Figure 4. Comparison of the results of $^{206}\text{Pb}/^{238}\text{U}$ ratio analyses for the dynamic simulation model and the traditional model. This figure shows that the closed system model will underestimate the age when the age is less than the critical year. Conversely, it will overestimate the age when the age of mineral exceeds the critical year.

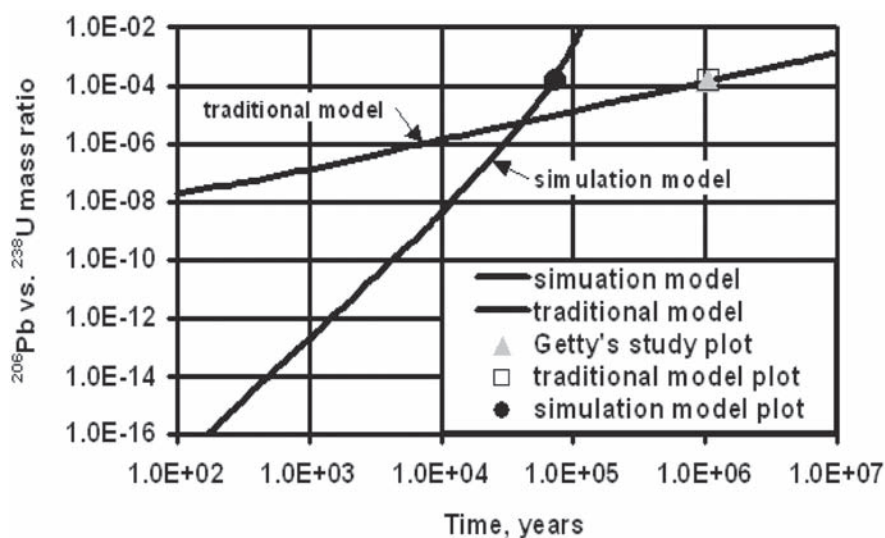


Figure 5. Comparison of the results of existing dating study for a rhyolite from the Cobb Mountain volcanic field using Getty and DePaolo's approach, dynamic simulation model, and traditional model. The results obtained from the traditional model are practically identical to the result obtained from Getty and DePaolo's study. However, the dating result obtained from the dynamic simulation model is much smaller than that reported in Getty and DePaolo's study. The relative error is as high as 92.9%.

obtained from Getty and DePaolo's study are added to Figure 4 and presented in Figure 5. The results obtained from the traditional model are practically identical to that reported in Getty and DePaolo's study. However, there are significant differences between the ages obtained from simulation model and that from Getty and DePaolo's study. These differences are caused by the fact that the simulation model considers the transport of radionuclides out of the mineral deposit, whereas Getty and DePaolo's study did not. The relative error is calculated to be on the order of 92.9%.

Conclusions

A 3-D dynamic simulation model that takes into consideration the dynamic transport of radionuclides associated with decay/ingrowth processes has been developed. This model is verified for both the decay/ingrowth and for the transport components. The results of model verification indicate that there are close agreements between the results of simulation and analytical solutions, implying that the model is valid and accurate.

In order to demonstrate the performance of the model, the time variation of $^{206}\text{Pb}/^{238}\text{U}$ ratios are analyzed for both using the dynamic simulation model and the traditional model. The results of analyses indicate that the traditional model will underestimate the age of mineral when the ages are below the

critical year and, conversely, will overestimate the age when the age exceeds the critical year. These overestimates or underestimates are caused by the crude assumptions (closed-system assumption and ultimate-equilibrium assumption) being imposed on the traditional model to simplify the processes of model analysis. Since the range of age interest is normally greater than the critical year, one may claim that the traditional model will, in general, overestimate the age of mineral.

The result of comparison with the existing study conducted for the Alder Creek rhyolite by Getty and DePaolo also experienced the same result, 0.0735 Ma from simulation model versus 1.03 Ma from Getty and DePaolo's study. This is because Getty and DePaolo's study also had imposed the closed-system and ultimate-equilibrium assumptions.

The conclusions of the study thus include that for many samples traditionally given millions of years of age by evolutionists, the age is reduced when

the more realistic diffusion and flow models are used. However, they are not necessarily reduced by the amounts that a biblical time frame would require.

Appendix A. The Model Used for Numerical Analysis

Radionuclide Decay Subroutine

A quasi-analytical scheme is employed for the numerical analysis of the decay/ingrowth component to improve the accuracy of simulation. This scheme employs the well-known analytical solution derived by Bateman (Bateman, 1910; and Evans, 1967, p. 490) to calculate the increment of radionuclides concentration. Furthermore, to improve the accuracy of numerical analysis, the calculation for each time step is subdivided into two parts, with each part accounting for the effects accrued in one-half of the time step. With a maximum of five decay-chain members and with a time increment of $0.5\Delta t$, the concentration of each radionuclide in the decay chain takes the form:

$$\begin{aligned}
c_1(t - 0.5\Delta t, x, y, z) &= c_1(t - \Delta t, x, y, z) \text{Exp}(-\lambda_1 0.5\Delta t) \\
c_2(t - 0.5\Delta t, x, y, z) &= \lambda_1 c_1(t - \Delta t, x, y, z) \left(\frac{A_2 R_1}{A_1 R_2} \right) \left[\frac{\text{Exp}(-\lambda_1 0.5\Delta t)}{(\lambda_2 - \lambda_1)} \right. \\
&\quad \left. + \frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_1 - \lambda_2)} \right] + c_2(t - \Delta t, x, y, z) \text{Exp}(-\lambda_2 0.5\Delta t) \\
c_3(t - 0.5\Delta t, x, y, z) &= \lambda_1 \lambda_2 c_1(t - \Delta t, x, y, z) \left(\frac{A_3 R_1}{A_1 R_3} \right) \left[\frac{\text{Exp}(-\lambda_1 0.5\Delta t)}{(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} \left. \right] + \lambda_2 c_2(t - \Delta t, x, y, z) \left(\frac{A_3 R_2}{A_2 R_3} \right) \left[\frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_3 - \lambda_2)} \right. \\
&\quad \left. + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_2 - \lambda_3)} \right] + c_3(t - \Delta t, x, y, z) \text{Exp}(-\lambda_3 0.5\Delta t) \\
c_4(t - 0.5\Delta t, x, y, z) &= \lambda_1 \lambda_2 \lambda_3 c_1(t - \Delta t, x, y, z) \left(\frac{A_4 R_1}{A_1 R_4} \right) \left[\frac{\text{Exp}(-\lambda_1 0.5\Delta t)}{(\lambda_4 - \lambda_1)(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} \\
&\quad + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)(\lambda_1 - \lambda_4)} \left. \right] + \lambda_2 \lambda_3 c_2(t - \Delta t, x, y, z) \left(\frac{A_4 R_2}{A_2 R_4} \right) \left[\frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)} + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)} \left. \right] + \lambda_3 c_3(t - \Delta t, x, y, z) \left(\frac{A_4 R_3}{A_3 R_4} \right) \left[\frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_4 - \lambda_3)} \right. \\
&\quad \left. + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_3 - \lambda_4)} \right] + c_4(t - \Delta t, x, y, z) \text{Exp}(-\lambda_4 0.5\Delta t) \\
c_5(t - 0.5\Delta t, x, y, z) &= \lambda_1 \lambda_2 \lambda_3 \lambda_4 c_1(t - \Delta t, x, y, z) \left(\frac{A_5 R_1}{A_1 R_5} \right) \left[\frac{\text{Exp}(-\lambda_1 0.5\Delta t)}{(\lambda_5 - \lambda_1)(\lambda_4 - \lambda_1)(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_5 - \lambda_2)(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_5 - \lambda_3)(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} \\
&\quad + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_5 - \lambda_4)(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)(\lambda_1 - \lambda_4)} + \frac{\text{Exp}(-\lambda_5 0.5\Delta t)}{(\lambda_4 - \lambda_5)(\lambda_3 - \lambda_5)(\lambda_2 - \lambda_5)(\lambda_1 - \lambda_5)} \left. \right] \\
&\quad + \lambda_2 \lambda_3 \lambda_4 c_2(t - \Delta t, x, y, z) \left(\frac{A_5 R_2}{A_2 R_5} \right) \left[\frac{\text{Exp}(-\lambda_2 0.5\Delta t)}{(\lambda_5 - \lambda_2)(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_5 - \lambda_3)(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)} + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_5 - \lambda_4)(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)} \\
&\quad + \frac{\text{Exp}(-\lambda_5 0.5\Delta t)}{(\lambda_4 - \lambda_5)(\lambda_3 - \lambda_5)(\lambda_2 - \lambda_5)} \left. \right] + \lambda_3 \lambda_4 c_3(t - \Delta t, x, y, z) \left(\frac{A_5 R_3}{A_3 R_5} \right) \left[\frac{\text{Exp}(-\lambda_3 0.5\Delta t)}{(\lambda_5 - \lambda_3)(\lambda_4 - \lambda_3)} \right. \\
&\quad + \frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_5 - \lambda_4)(\lambda_3 - \lambda_4)} + \frac{\text{Exp}(-\lambda_5 0.5\Delta t)}{(\lambda_4 - \lambda_5)(\lambda_3 - \lambda_5)} \left. \right] + \lambda_4 c_4(t - \Delta t, x, y, z) \left(\frac{A_5 R_4}{A_4 R_5} \right) \left[\frac{\text{Exp}(-\lambda_4 0.5\Delta t)}{(\lambda_5 - \lambda_4)} \right. \\
&\quad \left. + \frac{\text{Exp}(-\lambda_5 0.5\Delta t)}{(\lambda_4 - \lambda_5)} \right] + c_5(t - \Delta t, x, y, z) \text{Exp}(-\lambda_5 0.5\Delta t)
\end{aligned}$$

In the above equations, A is the atomic weight of the radionuclide, R is the retardation factor, c is the concentration of radionuclide, and the subscripts 1, 2, 3, 4, 5 designate the order of progeny in the decay chain. *Retardation factor* refers to the ratio of the migration velocity of water in the geological medium to that of radionuclide being carried. It is always larger than unity since the sorption of radionuclide by solid particles in the medium impedes the migration of radionuclide. The computer code for this process is implemented in the “decay” subroutine program.

Boundary Condition

Since this model deals with dispersion as the primary nature of transport, the radionuclide concentration at the boundary can be calculated by assuming the ratio of concentrations at the boundary and at the previous nodal point is a fixed fraction of the same ratio measured at the previous node. Based on the above assumption, the concentration of radionuclide at the boundary nodal point can be calculated from the concentration at the previous nodal point by:

$$c(t, E, x_1, x_2) = c(t, E-1, x_1, x_2) \cdot \eta \left[\frac{c(t, E-1, x_1, x_2)}{c(t, E-2, x_1, x_2)} \right] \quad (A2)$$

in which, η is the dispersion tail coefficient, which is the fraction of the ratio of concentrations described above, E is the nodal point at the boundary, $E-1$ and $E-2$ are respectively the first and second nodal points immediately next to the boundary node, and x_1 and x_2 are the nodal points with respect to the other two axes.

Theoretically, the dispersion tail coefficient should vary with time, location of the diffusion plume tail, and characteristics of the diffusion plume. However, if the point is selected far enough from the diffusion source and the prime nature of the transport is limited to the dispersion, then the coefficient can be narrowed down to a very small range. An observation of more than 40 collected dispersion plume tail data indicates that these values fluctuate between 0.95 and 0.98. Therefore, a conservative fixed value of 0.98 is selected for this simulation model.

Appendix B. Bateman Equations

The Bateman equation (Bateman, 1910; Evans, 1967, P. 490) is used for the decay/ingrowth analysis. The number of atom at t target year takes the form:

$$\begin{aligned} N_1 &= N_{01} \text{Exp}(-\lambda_1 t) \\ N_2 &= \lambda_1 N_{01} \left[\frac{\text{Exp}(-\lambda_1 t)}{(\lambda_2 - \lambda_1)} + \frac{\text{Exp}(-\lambda_2 t)}{(\lambda_1 - \lambda_2)} \right] \\ N_3 &= \lambda_1 \lambda_2 N_{01} \left[\frac{\text{Exp}(-\lambda_1 t)}{(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} + \frac{\text{Exp}(-\lambda_2 t)}{(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} + \frac{\text{Exp}(-\lambda_3 t)}{(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} \right] \\ N_4 &= \lambda_1 \lambda_2 \lambda_3 N_{01} \left[\frac{\text{Exp}(-\lambda_1 t)}{(\lambda_4 - \lambda_1)(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} + \frac{\text{Exp}(-\lambda_2 t)}{(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} \right. \\ &\quad \left. + \frac{\text{Exp}(-\lambda_3 t)}{(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} + \frac{\text{Exp}(-\lambda_4 t)}{(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)(\lambda_1 - \lambda_4)} \right] \\ N_5 &= \lambda_1 \lambda_2 \lambda_3 \lambda_4 N_{01} \left[\frac{\text{Exp}(-\lambda_1 t)}{(\lambda_5 - \lambda_1)(\lambda_4 - \lambda_1)(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} \right. \\ &\quad + \frac{\text{Exp}(-\lambda_2 t)}{(\lambda_5 - \lambda_2)(\lambda_4 - \lambda_2)(\lambda_3 - \lambda_2)(\lambda_1 - \lambda_2)} + \frac{\text{Exp}(-\lambda_3 t)}{(\lambda_5 - \lambda_3)(\lambda_4 - \lambda_3)(\lambda_2 - \lambda_3)(\lambda_1 - \lambda_3)} \\ &\quad \left. + \frac{\text{Exp}(-\lambda_4 t)}{(\lambda_5 - \lambda_4)(\lambda_3 - \lambda_4)(\lambda_2 - \lambda_4)(\lambda_1 - \lambda_4)} + \frac{\text{Exp}(-\lambda_5 t)}{(\lambda_4 - \lambda_5)(\lambda_3 - \lambda_5)(\lambda_2 - \lambda_5)(\lambda_1 - \lambda_5)} \right] \end{aligned} \quad (B1)$$

where N is the number of atom, λ is the decay constant, t is the target year, subscripts 1, 2, 3, 4, and 5 represent the sequence of decay chain members, and subscript 0 denotes the initial value.

Acknowledgments

The author would like to express his sincere gratitude to Dr. Jing Chang Chen, Dr. Hansen Su, and Professor Liang Chi Hsu for their valuable advice and suggestions throughout this study.

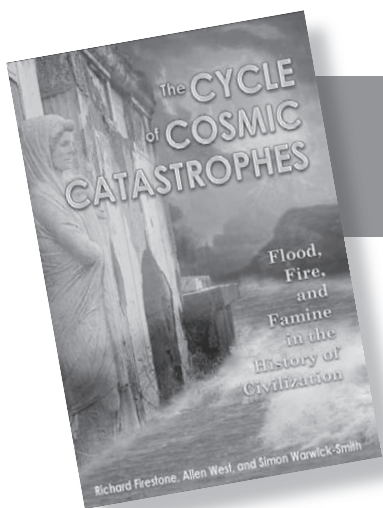
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Erratum

In “Origins of Apoptosis,” page 207 of the Winter 2008 CRSQ, the statement should be: “Cells (such as melanin cells) that are not prone to UV damage produce very small amounts of apoptosis-inhibiting Bcl-2 protein.”



Book Review

The Cycle of Cosmic Catastrophes

by Richard Firestone,
Allen West, and Simon
Warwick-Smith

Bear & Company, Rochester,
VT, 2006, 416 pages, \$20.00.

This book has a significant amount of original research on the extinction of the mammoths and the end of the Ice Age. The authors use mainstream radiocarbon dates but seem open to the idea that some dates might be wrong. On page 12 they comment about one date: "The most astounding Clovis-era site of all was at Grant Lake in Nunavut Province in northern Canada, where the long gone Ice Age Paleo-Indians had apparently been hunting mammoths during the time of the Battle of Gettysburg in the U.S. Civil War!" Mainstream science would probably dismiss the authors' reported finds (including photos) of pre-Clovis artifacts.

The authors assert that the Clovis people appeared suddenly in the New World for just a few hundred years and vanished at about the same time as the mammoths, mastodons, American camels, American horses, and saber-toothed tigers. They discuss the "ill, chill, and overkill" theories of explaining these extinctions. The book describes the discovery of several mammoth tusks, from both North America and Siberia, which

were embedded with tiny iron particles. Birdshot from a shotgun did not have the necessary velocity to penetrate the tusks, but they were able to get similar penetration with a particle accelerator. Likewise, they found a large number of chert flakes, waste from a Clovis spear maker, with embedded iron particles on one side only. They found the same particles in the top surface of drumlins, boat-shaped piles of rock, sand, and gravel that form under a melting ice sheet. They explain these observations with a "fluffball" comet, a large cloud of these iron particles. The leading edge would consume the oxygen and push most of the nitrogen out of the way, allowing the following particles to hit the earth with a speed of 3,000 to 4,000 miles per hour, perhaps five times the muzzle velocity of a shotgun. The particles would penetrate deeply into the ice sheets and eventually melt onto the tops of the drumlins. The density of the iron particles is such that the wind would be unable to erode them from a "natural" site and transport them to the top of the drumlin.

The particles also contain plutonium, (but not cesium-137), potassium-40, thorium, and uranium. Animals and people would experience suffocation, heat, and radiation poisoning, not to mention the physical damage to the body from the proposed particles if caught out in the open. It seems the authors have made a good case for these extinctions being caused by a comet. They also present considerable data on the Carolina Bays, shallow lakes in the eastern and southeastern United States that may have been formed by icy fluffball comets at about the same time as the extinctions. It is speculated that "earlier" extinctions (dinosaurs) might have been caused by a supernova exploding about 200 light years from the earth.

There are 17 pages of bibliography and a 7-page index.

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Notes from the Panorama of Science

Diamonds Are a World's Best Mend

Marilyn Monroe immortalized the phrase “Diamonds are a girl’s best friend” in her hit song from the movie *Gentlemen Prefer Blondes* in 1953. Creationists and Bible-believing Christians the world over would argue that Jesus Christ, the Savior of mankind, is certainly a better friend to girls and boys alike, but who does not love to look at a diamond? They sparkle with unmatched brilliance, their size and color command respect the world over, and who can forget that “a diamond is forever”? Everybody knows what a diamond is!

The properties of diamonds, the enigma of their source (and origins), and their uses are frequently discussed in the scientific literature. A few creationists have commented on diamond news coverage (Brown, 1997; Chaffin 1986; DeYoung 1982; Oard, 2004; Sarfati, 2006; Snelling, 1994, 1996); however only recently have creation scientists turned their attention to actually studying diamonds and their implications for a recent creation and a young earth (Baumgardner, 2005). In a world that needs mending badly, the message that may be contained in these tiny, almost impenetrable storage capsules could be one that all of mankind could stand to hear.

The history of diamonds as sought-after stones began in sixth-century India (the largest and earliest producer of diamonds), long before the first commercial diamond mine was dug in the late 1860s in South Africa (Meyer, 1985). At the time, India was producing all the diamonds that monarchs and merchants could buy, and yet diamonds were very rare—only a privileged few had them. The South African diamond

mines changed everything. Today, over 130 million carats (\$10–13 billion) of this precious stone are mined annually (Strom, 2007; personal communications. Mr. Strom works for The Gemological Institute of America in Carlsbad, CA.) It would be unimaginable to think that a marriage proposal would take place anywhere without a diamond-topped engagement ring at the ready. No one would argue that diamonds are not one of the most sought-after gemstones on earth today. DeBeers, a privately owned enterprise and probably the largest seller of diamonds in the world, had revenues of \$6.5 billion in 2005 alone. It launched a very successful marketing campaign in 1947 (“A Diamond Is Forever”), and the diamond market has never been the same (Phrase Finder, 2007).

The road to modern diamond production is a fascinating one, and a thorough treatment of the story can be viewed online at a web site maintained by the American Museum of Natural History (AMNH, 2007).

Man’s feeble attempts to synthesize diamonds in the laboratory have been met with some interesting success as far as small, industrial-use diamonds go (some estimates are as high as 100,000 carats per year), but in order to “grow” diamonds, carbon must be subjected to very high pressures and very high temperatures in the presence of transition metals (or some sort of seed) just to initiate the reaction (Gunn and Luth, 2006; Langenhorst, Poirier, and Frost, 2004; Zhou et al., 2006). DeBeers claims that its equipment can tell synthetic from natural diamonds, and this is still a much-argued point, but large (over 1

carat) synthetic gemstones do not seem to be forthcoming. Nevertheless, the future market for diamond sales seems assured.

And what does the Bible have to say about diamonds? If they have a message for us, could it be one that God would want us to read? The clear message of the Bible is that diamonds (*yahalom*) were *created* stones, inasmuch as they were found in the Garden of Eden, before sin and the Fall of man, before the Flood, and adorning Lucifer himself as he stood in the Garden (Ezek. 28:13.) If these are created stones that have somehow come to the surface of the earth from some violent process (maybe associated with the Flood), it may not be possible for man to recreate them, even with all of his intelligence and technology.

The question is, are they really 3 billion years old as some earth scientists claim (Stachel et al., 2006)? In some cases it is not known how diamond deposits formed (Banas et al., 2007; DeStefano et al., 2006; Leost et al., 2003; Stachel et al., 2004), and origin theories for diamonds are based on educated guesses about geologic processes operating some 100–200km (or more for “deep” diamonds) below the earth’s surface—well below the areas of the crust that man has actually drilled and sampled (Rice, 2003; Shirey, Richardson, and Harris, 2004; Tappert et al., 2005). The origin of the carbon source for diamond is also still very much debated (Banas et al., 2007; Gunn and Luth, 2006; Rice, 2003). To compound matters, micro diamonds (on the order of 50 Angstroms in diameter) have been found in the Allende meteorite.

Scientists suggest that they are formed in close binary stars and are thought to form at low pressures in layers of the stellar atmospheres (1000 to 2000 Kelvins) (Lewis et al. 1987).

Today diamonds are mostly found only by mining into cone-shaped “kimberlite” volcanic pipes and by searching for them in marine deposits and alluvial river fans that are thought to have arisen from the mantle and through the crust millions of years ago. Aside from the (observably different—see Gunn and Luth, 2006) diamonds grown in the laboratory, natural diamonds have never been observed during their formative phase.

It is well known, however, that natural diamonds (and some other crystalline materials) often encase smaller minerals within their crystalline matrix (known as “inclusions”—see Figures 1–3). (Synthetic diamonds also suffer from inclusions, but these are mostly metal fragments that were part of the manufacturing process—see, e.g., Langenhorst, Poirier, and Frost, 2004). These other minerals must have been present at the time the natural diamond was formed in order for the incorporation of it within the diamond matrix to be complete. Diamonds are almost completely chemically inert and are extremely resistant to any contamination or chemical exchange, which means they would have traveled through the earth’s mantle and crust carrying these inclusions, completely intact and unchanged by the 200 km ascent (Baumgardner, 2005; Dobrzhinetskaya et al., 2003; Meyer, 1985; Prompratred et al., 2004; Tappert et al., 2005). Therefore, according to standard origins theories for diamonds, they represent tiny “time capsules” safely delivering materials from deep in the earth to its surface for us to open and study today.

Yet diamond scientists frequently are confused by the types of inclusions that exist in diamonds. For example, it is well known that sulfides make up the most commonly occurring inclusions



Figure 1. Diamond fragment with inclusions (possibly zircons – white arrows), from Orapa mine (world’s largest diamond mine in Botswana, Africa). Magnification 300X; scale bar = 200 micrometers.

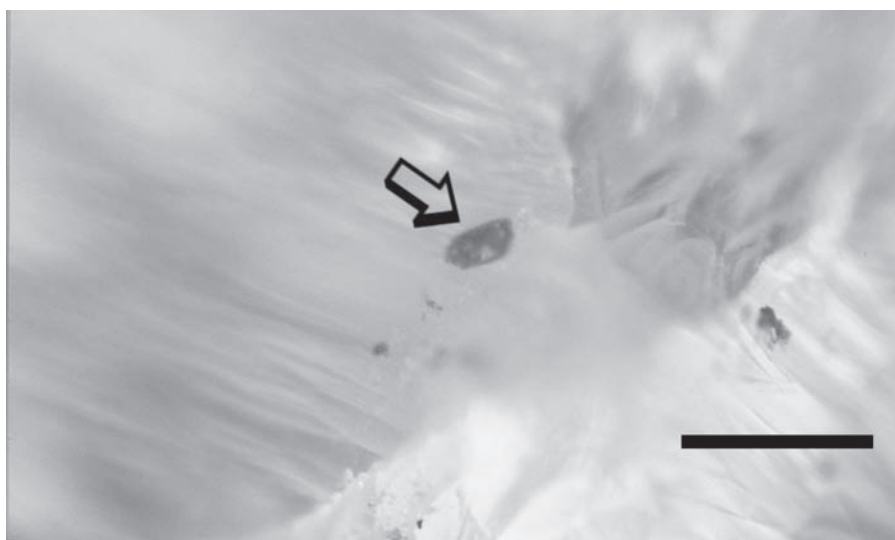


Figure 2. Diamond fragment with inclusion (unknown type), from Letlhakane mine (Botswana). Magnification 400X; scale bar = 50 micrometers.

in diamonds, which purportedly formed within the mantle, yet many rocks that supposedly come from the mantle contain little sulfides at all (Westerlund et al., 2004). In addition, it is mystifying as to how liquids, such as saline and water, and gases are encapsulated within diamonds from such depths (and such pressures) and brought to the surface

without expanding and destroying the diamond.

Inclusions consist of, but are not limited to, apatite, calcite, carbonates, chromitite, smaller diamonds, garnet, hematite, iron, mica, pyrite, pyroxene, silicates, sulfides, zircon, and, as mentioned, liquids (such as liquid CO₂, water, and even brine) and gases (Anony-



Figure 3. Diamond fragment with inclusions (garnets), from Orapa mine. Magnification 300X; scale bar = 200 micrometers.

mous, 2001; Anonymous, 2003; Klein Ben-David et al., 2007; Navon et al., 2003; Promprated et al., 2004; Stachel et al., 2004; Tappert et al., 2005; Tomlinson, Jones and Harris, 2006).

Frequently, inclusions found within crystalline rocks contain radioactive nuclides, such as uranium or thorium, embedded within the crystalline lattice of the inclusion. These radioactive nuclides eject alpha particles as a normal part of the radioactive decay process. Alpha particles travel some distance in the mineral (and then into the host rock), depending on the energy at which they were ejected from the nucleus of the nuclide, as well as the density of the crystalline material(s) they are found in. Some workers have even shown that the crystalline nature of inclusions, including zircons, may tend to become somewhat amorphous over time if continuous self-irradiation takes place (Nasdala et al., 2001; Nasdala et al., 2006).

The presence of zircons in diamonds is considered rare, but they have been previously reported (Kinney and Meyer, 1993, 1994). It may be that few reports of zircon inclusions have been made because they are not expected to be down

in the vicinity of the mantle, where it is thought by many that diamonds must form (Meyer, 1985). Most geologists believe that zircons exist mostly in the earth's crust, and since diamonds rise from the mantle to the crust, they would be already solidified and thus incapable of harvesting zircons from the crust on their way through (Baumgardner, 2007; personal communication). Nevertheless, zircon inclusions occur within diamonds and have been reported. Furthermore, there have even been reports of diamond inclusions within zircons (Dobrzhinetskaya et al., 2003; Kinney and Meyer, 1994), which certainly begs the formation question. Additionally, the techniques required to remove inclusions from diamonds are costly and destructive to the diamond (by crushing, see Banas et al., 2007; Tappert et al., 2005; and/or burning, see Promprated et al., 2004), thus many zircons in diamonds may go undiscovered simply because destroying diamonds is not an option for some diamond producers.

Zircons are known to contain radioactive nuclides (such as described above), and they are also well known in their role as radiocenters for radiohalos,

which have been observed in biotite, chlorite, cordierite, fluorite, sapphire, quartz, and other minerals (Coenraads, Sutherland, and Kinney, 1990; Ion et al., 2003; Nasdala et al., 2001; Nasdala, 2006; Pal, 2004; Snelling, 2005). Although one well-known researcher commented that he was not aware of any report describing uranium in diamond (Bozhilov, 2006; personal communication), zircon inclusions in sapphires are known to contain uranium, the parent radionuclide for polonium (Coenraads, Sutherland, and Kinney, 1990), and others have described such radioactive elements in other rocks from diamond-bearing kimberlites (Kramers, 1979).

Armitage (1993, 1995) reported clear, multi-ringed radiohalos in diamonds over fourteen years ago. Note the clarity of the diamond and the high contrast rings in Figures 4–8. No other widely published report has followed describing any radiohalos in diamonds, even though a span of fourteen years has elapsed. A platform presentation on radiohalos in diamonds was made at the Spring 2002 meeting of the American Geophysical Union (Vicenzi et al., 2002).

The diamond described in the 1993 study was made available for examination by the Gemological Institute of America (GIA). However as one diamond researcher with over 30 years experience stated, "Over decades of looking at millions of diamonds, I have only once seen a green set of haloes inside a stone" (J.W. Harris, 2007; personal communication).

Nevertheless, radioactive nuclide-bearing zircons must frequently exist in diamonds (and other gemstones) and most assuredly must produce radiohalos, even though they are not reported in the literature. Armitage and Snelling (2008), recently reported that the radioactive inclusions (and thus the radiohalos that resulted) were pushed into expanding cleavage planes by very hot hydrothermal fluids at or

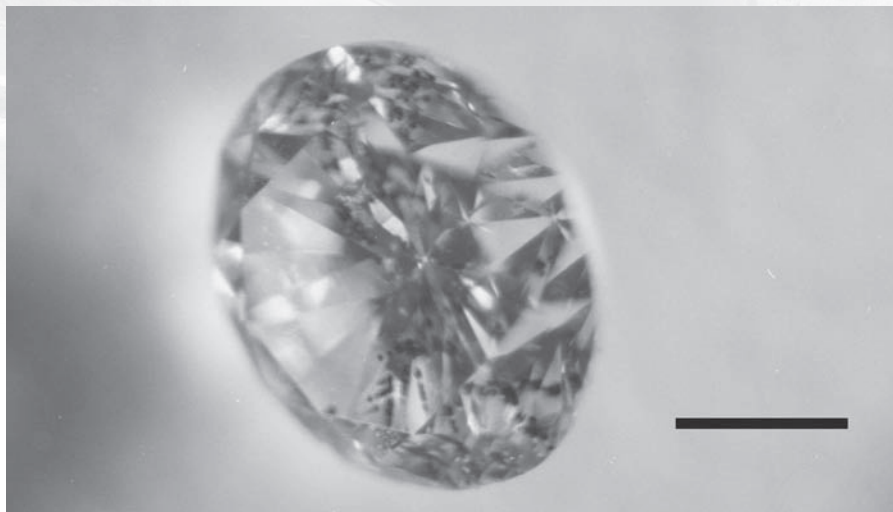


Figure 4. Round brilliant faceted diamond (origin unknown), courtesy of Gemological Institute of America. Clearly visible are the many radiohalos embedded in the diamond. Magnification 2X; scale bar = 1.25mm.

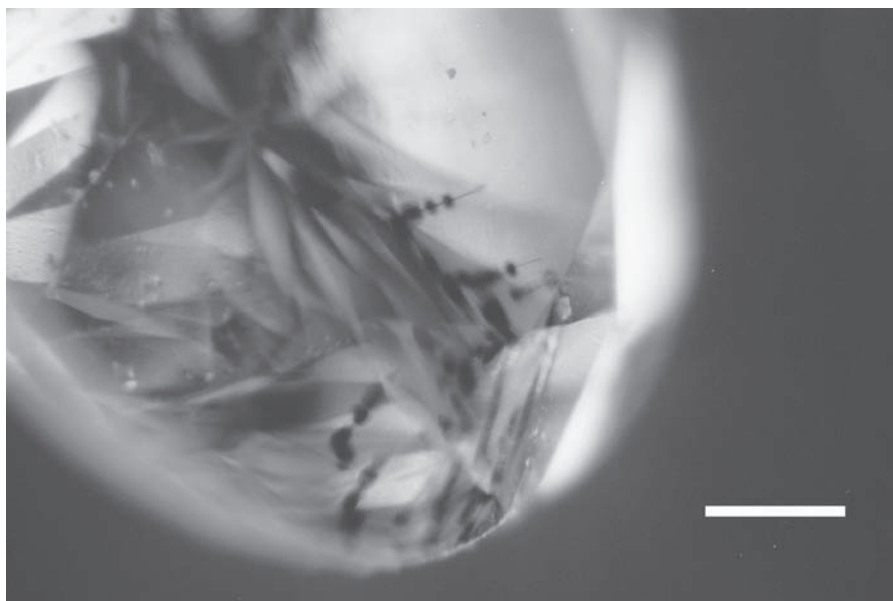


Figure 5. Round brilliant faceted diamond containing radiohalos. Note the halos are all connected at the center to a thin, straight "tube." The GIA notes that these "tubes" are actually crystalline inclusions, which do not make contact with the exterior surface of the diamond. Magnification 4X; scale bar = 0.5mm.

near the Earth's surface. More work is required to examine many diamonds to see if they too contain such radioactive halos. A suggestion could be made that the readers might examine their diamond engagement rings for such phenomena.

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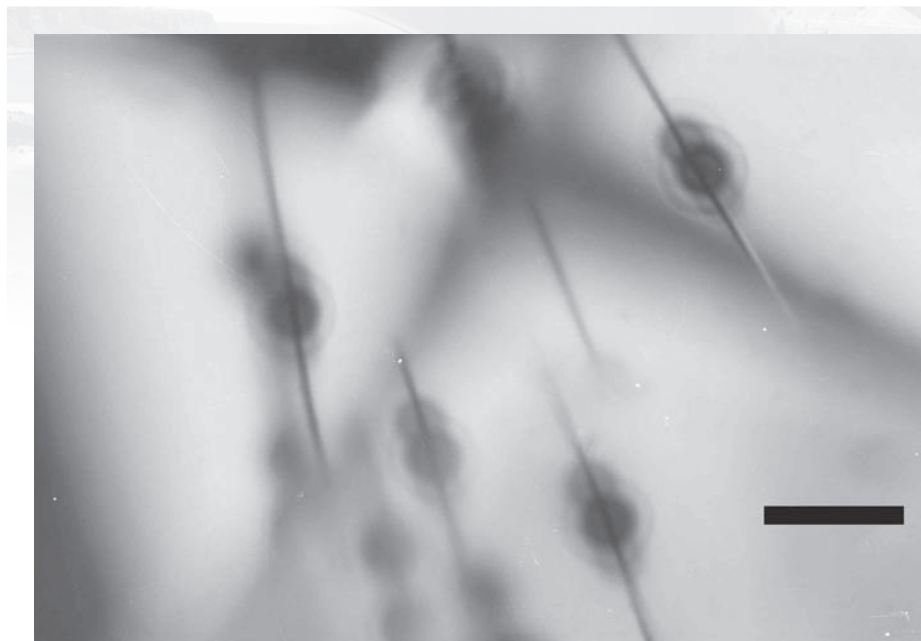


Figure 6. Higher magnification micrograph of the radiohalos in the diamond from Figure 1. Again the halos are transected by the solid inclusion “tubes.” Magnification 250X; scale bar = 75 micrometers.

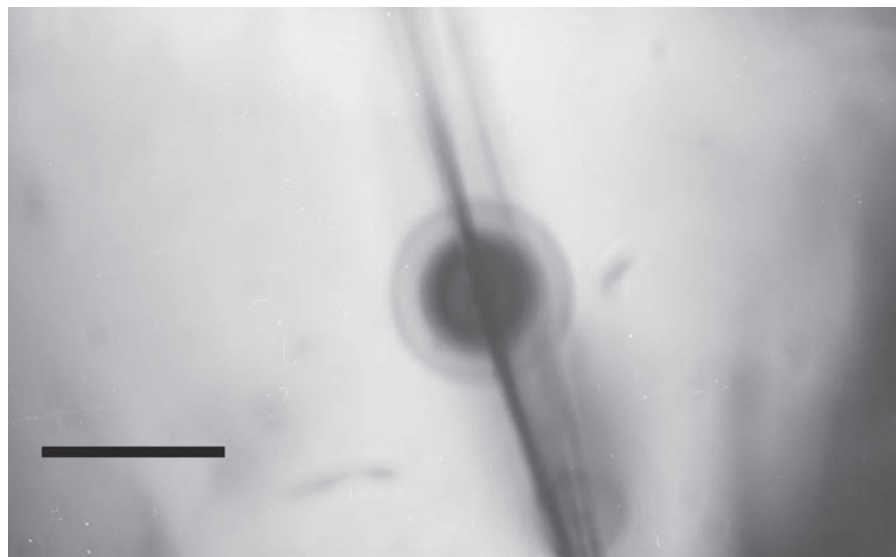


Figure 7. High magnification micrograph of radiohalos in diamond. Note that only three rings are visible, indicating that this may be a Polonium 218 halo. Magnification 400X; scale bar = 50 micrometers.

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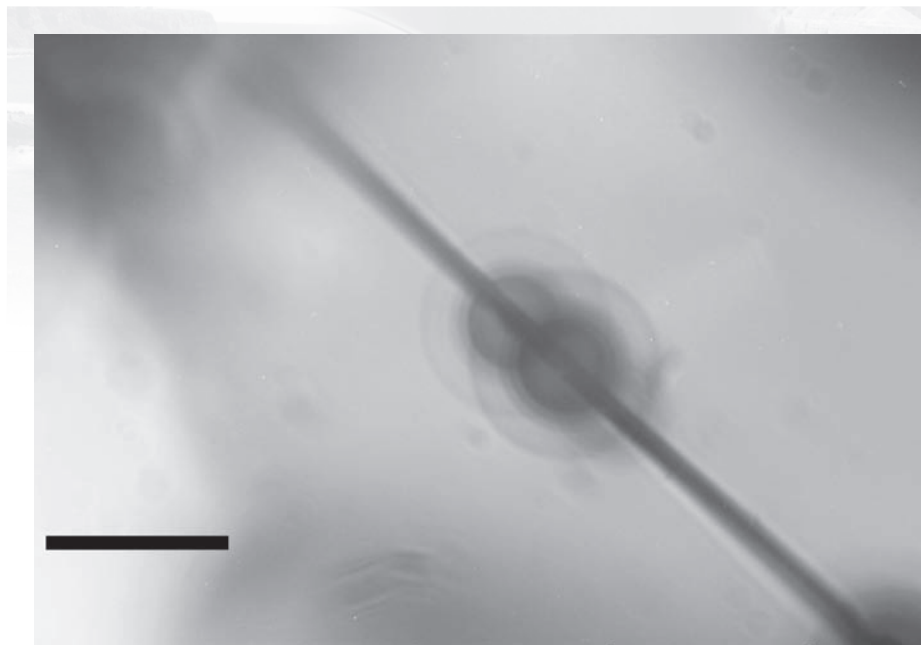


Figure 8. High magnification micrograph of radiohalos in diamond. Note that four rings are visible, indicating that this may be a Thorium halo. Magnification 400X; scale bar = 50 micrometers.

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Calcium Carbonate Glaebules: Paleosol Indicators or Groundwater-Derived Features?

Introduction

No one would argue that Earth has a history. However, disagreements occur in the interpretation of the rocks in defense of a certain perspective (e.g., old versus young Earth). Can creationists conduct geological studies using the same physical evidence as noncreationists and yet derive completely different and scientifically valid interpretations consistent with a young Earth? The answer is a definite yes! One such example is the occurrence of calcium carbonate glaebules in soils.

Paleosols are defined as fossil soils (see Froede, 2007). Uniformitarians contend that they reflect Earth's ancient history and can convey the atmospheric setting in which soils developed. In applying the axiom "the present is the key

to the past," uniformitarians believe that the top-down soil-forming processes occurring today (Figure 1) can be carried back in time to define paleosols. However, in many instances what is inferred from modern settings has not been empirically demonstrated to relate to paleosols. What appears to be an objective means of conducting an investigation actually turns out to be subjective and not based on scientific facts but on philosophical assumptions.

Carbonate glaebules (Figures 2a and 2b) are interpreted by soil scientists as features that develop in arid desert environments from surface-down soil-forming processes operating over many thousands of years. This approach was used by Lehman (1989; 1990) to explain calcium carbonate glaebules found in

certain stratified horizons across Big Bend National Park in southwestern Texas (Figure 3). We will discuss the use of calcium carbonate glaebules as paleosol indicators, specifically, how they form and whether they can be defined within the framework of a young Earth and global Flood.

What Are Glaebules?

According to Neuendorf et al. (2005), a glaebule is

a three-dimensional unit, usually prolate to equant in shape, within the matrix of a soil material, recognizable by its greater concentration of some constituent, by its difference in fabric as compared with the enclosing soil material, or by its distinct boundary with the enclosing soil material; e.g.,

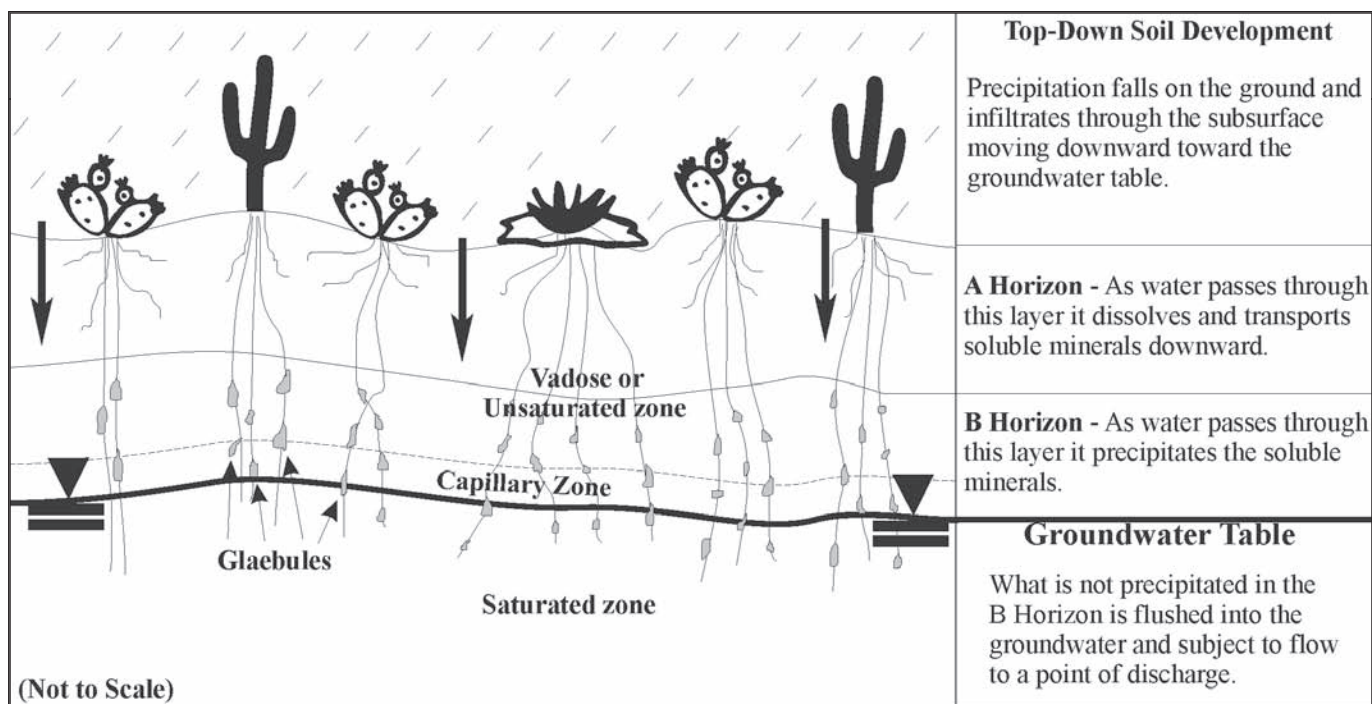


Figure 1. A generalized diagram showing the processes involved in the top-down transfer of minerals in the development of a soil profile. Pedologists and paleopedologists believe that this soil-forming process can take hundreds to millions of years (see Froede, 2007). Glaebules would nucleate in the B Horizon on plant roots, having been derived from minerals dissolved at the ground surface and from the A Horizon.

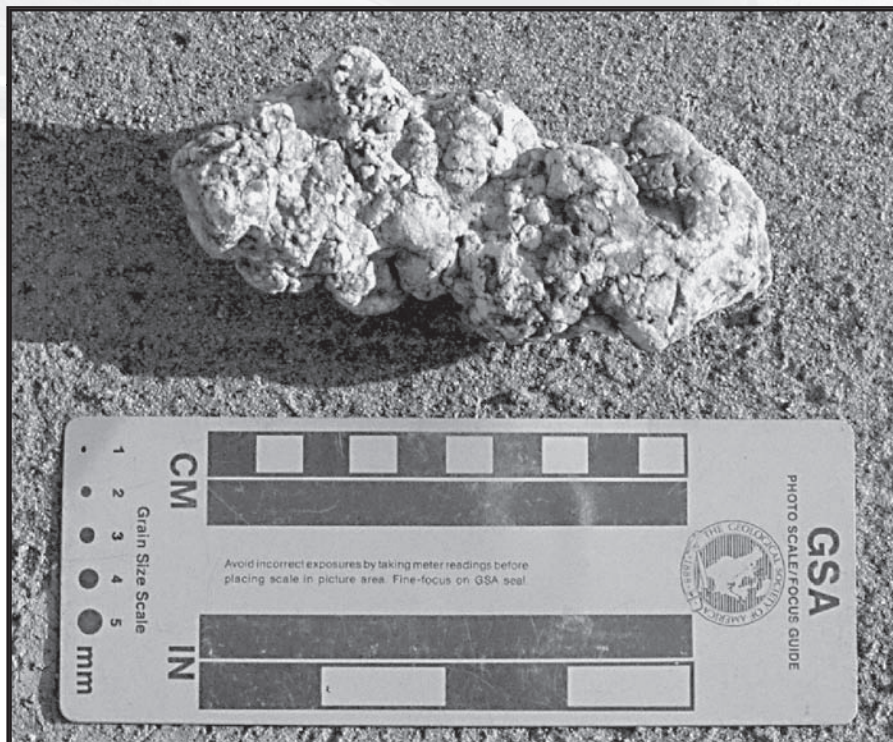


Figure 2a. A large calcium carbonate glaebule exposed on the ground surface in the area of Dawson Creek, Big Bend National Park, Texas. Scale in inches and centimeters.

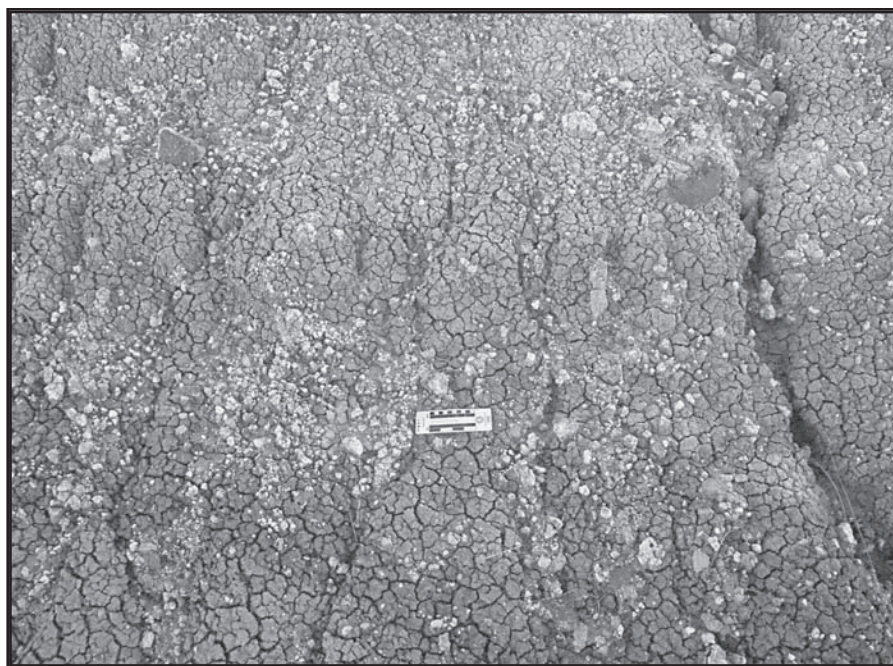


Figure 2b. Moisture in the bentonite clays in the Aguja Formation causes them to swell and form extensive cracks across the exposed surface. Carbonate glaebules (white masses) weather from the clays. Scale in inches and centimeters.

a nodule, concretion, septarium, pedode, or papule. (p. 273)

Paleopedologist Retallack (1990) defined glaebules as

naturally segregated lumps of soil material formed of the same wide variety of materials as cutans. *Common examples are the calcareous nodules of desert soils.* Glaebules range from highly irregular to almost spherical in shape and also vary in their distinctness and internal structure, but can be distinguished from cutans by their nonplanar shapes and generally more distinct outlines. Two common kinds of glaebules are *nodules* and *concretions*. These two terms are widely confused as synonyms, but for soil science are distinguished on the basis of their internal structure. A nodule is massive internally whereas a concretion contains concentric layers. (pp. 44–45, italics added)

We focus on glaebules defined as calcium carbonate encrustations thought to initiate on plant roots due to the precipitation of carbonate cements within the soil substrate (Lehman, 1989, Nichols, 1999). These features are of interest to paleopedologists as in many instances they are believed to reflect paleosol horizons in the subsurface (Retallack, 1990, 1997).

Australian pedologists Brewer and Sleeman (1964) are credited with defining glaebules within the context of soil science. Their analysis was based on the earlier work of sedimentologist Francis J. Pettijohn (1949), who defined various sedimentary features as “accretionary structures.” Brewer and Sleeman (1964) redefined these features (e.g., concretions, nodules, and glaebules) within the purported uniformitarian framework of slow-forming, surface-down soil development. However, even in his later revised work, Pettijohn (1975) never thought that these features were the result of soil-forming processes, but rather likely formed by groundwater geochemical changes.

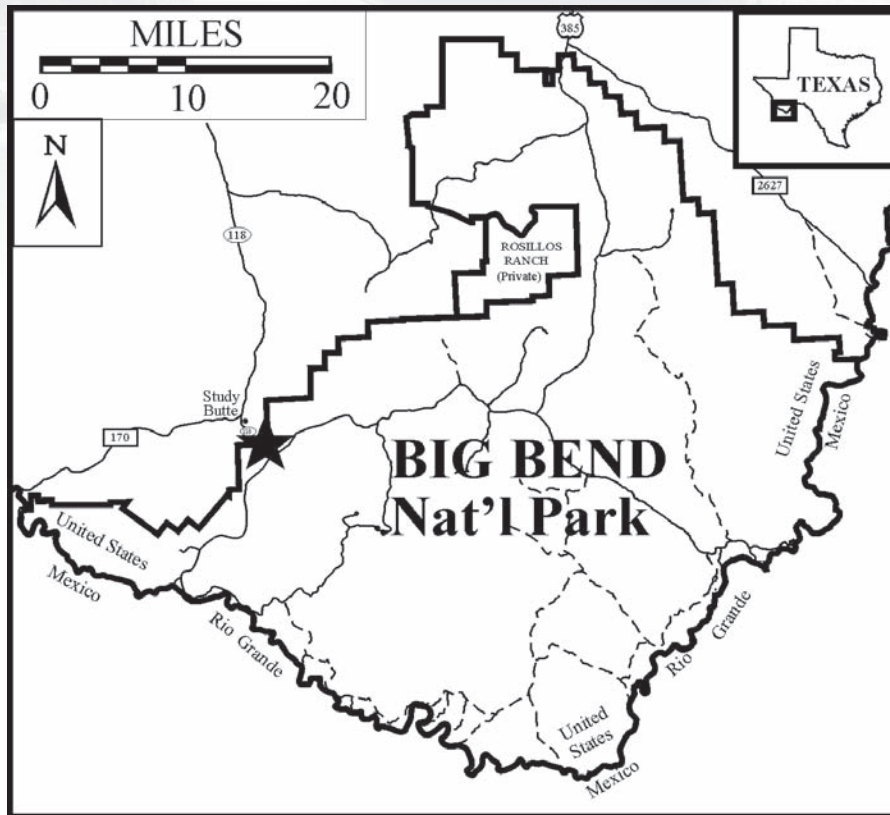


Figure 3. Big Bend National Park has been a research laboratory for uniformitarians and young-Earth creationists. Our particular study was conducted in the Dawson Creek area, indicated by the star. Lehman's work (1989, 1990) extended across the northern portion of the park and included Dawson Creek.

Paleosols and Glaebules at Big Bend National Park, Texas

In the late 1980s, Lehman conducted extensive fieldwork across portions of Big Bend National Park in southwestern Texas (Figure 4). From this work, he proposed that multiple paleosols occur throughout the Upper Cretaceous Aguja and Javelina Formations (1989) and also in the overlying Paleocene Black Peaks Formation (1990). His interpretation was based on changes in both soil color and paleontological content, and the presence of calcium carbonate glaebules along certain stratigraphic contacts. Lehman (1989) proposed that the glaebules formed around plant roots and could thus be interpreted as paleosols. However, no plant root material was reported in any of the glaebules that were examined.

We previously suggested that the changes in sediment color were diagenetic changes caused by changes in groundwater geochemistry and not by surface-down soil-forming processes (Howe et al., 2003). Can calcium carbonate glaebules be explained in this same manner rather than from soil development in an arid environment over extended periods of time?

Paleopedology or Hydrogeology: Which Perspective?

Perhaps the best way to understand the differences in the formation of calcium carbonate glaebules is in understanding the different perspectives between soil scientists who study ancient soils (i.e., paleopedologists) and geologists who

study the movement of groundwater within the subsurface (i.e., hydrogeologists). Paleopedologists link the atmospheric conditions, environments, and associated soil types found today and project them back in time. They infer that modern soil development requires many years, so paleosols also imply extreme periods of time (even though Klevberg et al. [in press] note that observations have proven that most soil-forming processes take much less time than uniformitarians believe). For example, regarding the development of paleosols across Big Bend National Park, Lehman (1989) stated:

On the basis of degree of development of the argillic [clay alteration] and petrocalcic [carbonate glaebule] horizons, each of these periods of soil formation must have been of at least several thousand years duration. Such long-term climatic cyclicity has been inferred for Late Cretaceous time, on the basis of limestone/shale rhythms observed in pelagic marine carbonate successions. These sedimentary cycles are thought to reflect alternating arid and humid climatic regimes induced by regular variations in the Earth's orbit. The so-called Milankovitch cycles include cycles with periods of 21,000 yr (precession), 41,000 yr (obliquity), 100,000 and 400,000 yr (eccentricity). It is conceivable that the long-term climatic cyclicity suggested by the Trans-Pecos paleosols may be the terrestrial counterpart to corresponding sedimentary cycles observed in the marine realm. The absence of any clear correlation of the proposed cycles within the Trans-Pecos region, however, allows no substantiation for this possibility at present. (pp. 201-202, brackets added)

Despite this rather confusing means of linking different uniformitarian inferences of astronomical cycles on sediment chemistry (Oard, 1984; 1985;



Figure 4. An exposure of the Javelina Formation (Upper Cretaceous) along Dawson Creek. Calcium carbonate glaebules that have formed along the contacts between some of these diagenetically altered clay layers have been used by uniformitarians to postulate former paleosol horizons (Lehman, 1989, 1990). Young-Earth creationists would counter this claim with the proposal that the color changes reflect the effects of groundwater geochemistry (Howe et al., 2003), and it is not unreasonable to believe the calcium carbonate glaebules developed under these same hydrogeologic conditions.

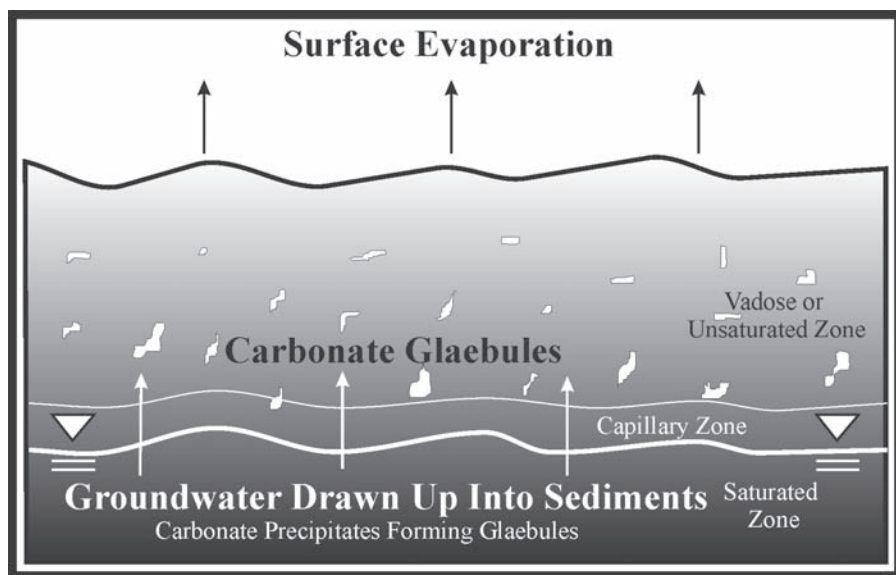


Figure 5. This diagram shows the hydrogeologic (i.e., hydromorphic) means of forming glaebules within the subsurface. Calcium carbonate saturated groundwater is drawn upward by capillary forces into the vadose zone (unsaturated zone) where pH/Eh changes occur and the carbonate is precipitated, forming glaebules (white masses). The end result of this process is the development of a carbonate caliche layer within the subsurface. Note that this process is different from the pedological top-down dissolution and transfer of carbonate in the subsurface (compare to Figure 1). Modified from Nichols (1999, p. 126, Figure 9.18).

1997; Vardiman, 1996), and using those highly questionable “clocks” to defend the extended timing of the development of multiple soil horizons across Big Bend National Park, uniformitarian hydrogeologists have long realized that subsurface sediments can be diagenetically altered in a manner similar to that of surface-down soil-forming processes simply by a fluctuating groundwater table (e.g., Pimentel et al., 1996; Kraus, 1999).

Groundwater-Derived Glaebules

Recent work specific to the formation of calcium carbonate glaebules suggest that they can form by the precipitation of minerals derived from groundwater (Slate, 1998; Nichols, 1999; see Figure 5). The environment does not need to be arid; all that is required is a near-surface seasonally fluctuating water table and evaporation. Within this environment, capillary forces would draw carbonate-saturated groundwater up into the vadose zone, where calcium carbonate would precipitate and form glaebules. According to Nichols (1999, p. 126), the end result of this process is a “thick calcrete horizon” in the shallow subsurface.

Slate (1998) believes that in many instances carbonate glaebules are improperly interpreted as developing from surface-down soil-forming processes.

In summary, paleosols that I believe formed within the influence of the ground-water table (Hydromorphic) have carbonate and clay accumulations and colors unlike those found in modern, well-drained surface soils. Most of the profile consists of carbonate segregated into large subspherical masses distributed throughout horizons that have a non- or weakly calcareous matrix. Colors vary from reddish to greenish to a combination of the two. Depositional environments and O [Oxygen] and C [Carbon] isotopic compositions support this conclusion.

Interpreting carbonate origin in paleosols helps to reconstruct paleoenvironments. But too often the 'per descendum model' is assumed, stages of carbonate development are assigned, and the degree of maturity is assessed, possibly leading to an erroneous interpretation of a drier climate or a slower sedimentation rate. I suggest reserving the use of morphologic stages of carbonate development á la Gile et al. (1966) and Machette (1985) for those paleosols where the evidence indicates that vadose soil processes occurred. (p. 61, brackets added)

Conclusion

Glaebules can be interpreted differently by uniformitarian pedologists and hydrogeologists. The determination of the carbonate source is important in understanding the processes ultimately responsible for glaebule development. The differences between soil-forming and groundwater-forming processes also have bearing on the question of glaebule development. Pedologists interpret these features as requiring thousands to potentially millions of years to form (e.g., Lehman, 1989; 1990), while hydrogeologists would opt for a much shorter period of development, probably not extending more than a few hundred years. From a hydrogeologic standpoint, glaebule formation would simply reflect changing geochemical conditions in groundwater and the fluctuation of the potentiometric surface in the subsurface.

The area encompassing Big Bend National Park was certainly more temperate in climate following the Flood than it is today. It would have been more conducive to groundwater-derived glaebules than to Lehman's model. A fluctuating groundwater table saturated with calcium carbonate derived from the local limestones both underlying and surrounding the area would provide a

ready source of carbonate that could be precipitated in the shallow subsurface. The glaebules were likely derived from a fluctuating groundwater table coupled with pH/Eh changes in groundwater geochemistry, *not* millions of years of changing arid paleoenvironments. Thus, the old-Earth interpretation of paleosol formation is no more valid than the young-Earth groundwater interpretation. A diluvial framework explains both the diagenetic changes to the sediments and the formation of glaebules along specific stratigraphic horizons at Big Bend National Park.

Young-Earth creationists can use glaebules to define hydrogeologic processes that occurred within the subsurface following the Flood. Their development within the capillary fringe in the vadose zone could help determine former groundwater table elevations and possibly the flow direction within the zone of saturation.

Acknowledgments

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Book Review

Evolution: The Shadow of Creation

by Shaun Kauffeld

Books of the Way,
Menomonie, WI,
59 pages, \$4.00.

Shaun Kauffeld has been a pastor for 25 years and currently serves St. John's Lutheran Church, Spring Valley, Wisconsin and St. Katherine's Lutheran Church, Menomonie, Wisconsin.

The purpose of the book is to provide a simple means of understanding and dealing with the teaching of evolution for the common layperson. The teaching of evolution has caused much confusion in science classes and the media. Some authorities teach it as a fact, and those who question it are made to feel they are ignorant. Because of this, evolutionists have prevailed for many years. Yet, evolution is not a fact and has never been

observed or tested. It is a human theory that has been made and promoted as a result of improperly perceiving and understanding the shadow that creation left behind. Over time, that theory became the religion of those who wanted to believe that there was no God. It also became the compromise of some of those who believe in God.

In Chapter 1, Kauffeld relates some of the friendly arguments he has had with his evolutionary teachers. Then, in succeeding chapters, he covers the subjects "Does a Day Have to be a Day?" "Difficulties with Billions of Years,"

"Spontaneous Generation," "Change for a Purpose," "Fossil Records," "Is Creation an Apparent Lie?" and "What is the Strength of Evolution?"

The book's only weakness is that the author does not define and differentiate between microevolution, which is observable, testable, and falsifiable, and macroevolution, which has never been observed, tested, or falsified. Otherwise this is a good book for children, students, and all laypeople.

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God Saw That the Light Was Good: Light Production in *Photinus pyralis*

Bioluminescence is the production of light by living organisms, usually as a result of specific chemical reactions involving enzymes in which light is produced and emitted at “cold” or room temperatures. Living light is produced by several different organisms, most notably by specific bacteria, which often live in colonies inside certain fish and other organisms (Madigan and Martinko, 2005), free-floating plankton such as bacteria or dinoflagellates (Miller et al., 2005; Neelson and Hastings, 2006), insects, and in many instances, marine invertebrates (Rees et al., 1998).

Living tissues emit light when complex compounds react with oxygen (and ATP), releasing photons of light. An example of such a compound would be luciferin (from the Latin *Lucifer*, meaning light bearer). Luciferin is actually the generic name of a whole family of pigment compounds that are used in bioluminescence. Generally these reactions occur slowly at room temperature; therefore, many organisms also employ specific enzymes (or catalysts, such as luciferase), which accelerate the light-emitting reaction. Luciferase is also a generic name for the specific family of enzymes that break down luciferin (Baldwin, 1996). Many of the bioluminescence methods employed by living organisms are extracellular, meaning the compounds are excreted outside of cells before light is produced (especially in shellfish). The more sophisticated method, however, appears to be intracellular luminescence such as produced by fireflies, or lightning bugs (Smith, 1963).

Luciferin and luciferase, the complicated compounds that most fireflies use to generate light, come in many forms. They are also involved in different types of chemical pathways that produce light. This causes problems for evolution theory, which requires them to be related by evolutionary descent. They thus should

look and act similarly, which is not the case. The evolutionary (or naturalistic) origins explanation tendered by evolutionists usually presupposes convergent (or parallel) evolution (Day and Bailey, 2003; Rees et al., 1998). The belief that these disparate and elegant chemical pathways and complex compounds arose over and over again in different organisms is actually no explanation.

One worker concluded that bioluminescence evolved *30 different times* in such diverse organisms as worms, gnats and beetles, bacteria, dinoflagellates, fish, shellfish, and many kinds of marine invertebrates (Vivianni, 2002). The genes that code for the luciferin-regenerating enzyme (LRE protein) in *Photinus pyralis* (the firefly subject of this study) possess close similarity to some mammalian genes, including those of humans, cows, and rabbits (Day and Bailey, 2003). A logical evolutionary source, however, eludes their study; thus much confusion reigns in the field.

One early worker asserted that “bioluminescence arose as an accidental byproduct of oxygen detoxification when photosynthetic oxygen started to rise in the atmosphere” (Seliger and McElroy, 1965; see also McElroy and Seliger, 1962). However, evolutionists now commonly believe that living light production arose on land over 200 million years ago, either for the purpose of mate attraction (sexual selection) or to warn potential predators of their distastefulness (Buck and Case, 2002). In the oceans it is thought that bioluminescence was again newly evolved “when marine organisms began colonizing deeper layers of the oceans” (Rees et al., 1998). Nevertheless, researchers remain committed to the “fact” that it evolved independently and unpredictably in over 30 very different organisms in various environmental niches (Buck and Case, 2002; Day and Bailey, 2003; Rees et al., 1998; Vivianni, 2002).

The luciferin/luciferase system has important modern uses in the fields of medicine and agriculture. This complex is now commonly used as a light-emitting probe that can be inserted genetically into living systems (*in vivo*) in order to image certain cellular functions. Scientists can observe in real time the activity of infectious diseases, tumor growth, viral infections, and genetic plant transformation when the genes that code for the bioluminescence cell machinery are expressed (Harwood et al., 2002; Kratzer et al., 2001; Rice, Cable, and Nelson, 2001). In fact, the oxidation of luciferin by luciferase is the most efficient bioluminescent system known—one photon of light is released for each molecule of luciferin oxidized (Keithley, 1990; Michel et al., 2001). Thus, very bright signals can be generated with only a few thousand luciferin molecules.

Luminescence in fireflies, and in particular the systematic *flashing* of light, is used most often for mate selection (Lloyd, 2000). Males flash in specific patterns while in flight in order to locate (often wingless) females, which rest on trees and bushes, mostly at twilight. Females respond to these signals by blinking their own abdominal lanterns in a similar pattern to attract males. In one genus, however (*Photuris*), females use “flashing mimicry” to attract, and then predate upon, males of the genus *Photinus* (Stous, 1997). Predation is a biological interaction where one organism (a predator) feeds on other organisms (known as prey). In this case, *Photuris* females attract males of a *different* genus (*Photinus*) by flashing just the right signals (i.e., posing as a *Photinus* female seeking a mate) only to eat them when they arrive. All of this remains unexplained by evolution theory.

The control mechanisms, tissue structure, and chemistry of this phenomenon are bewilderingly complex and



Figure 1. Adult firefly, *Photinus pyralis*, collected from Lynchburg, VA. SEM (scanning electron microscope) image. Dotted scale bar = 1.20 mm.

thus speak to us of intelligent design. For example, fireflies produce bioluminescence in various regions of the visible spectrum, but females have visual systems that are finely tuned to receive the actual particular wavelengths of light being produced by the males (Cronin et al., 2000; Lall and Worthy, 2000). The anatomy of light production in the firefly *Photinus pyralis* is covered here, but the particular structures employed, the chemistry involved (including the gases required for function), and the behaviors associated with this fascinating organism will be more deeply explored in future papers.

John Buck (1948) has produced a comprehensive description of the anatomy of firefly light production. This and other Buck publications will be referred to in the present work with respect to *Photinus pyralis* (Figures 1 and 2). The light organs of *P. pyralis* are very complex and are found just below the sixth and seventh sternites (see Figure 3, black arrows) of each male and female (but sometimes not the seventh in females) cuticle (Buck, 1948). These sternites are translucent to the light that



Figure 2. SEM image of an adult firefly showing sternites (segments) under which the light emitting tissues lie (white arrow). Scale bar = 3.0 mm.

passes through them to the environment, but they appear opaque to the microscope and the eye alike (Figures 3 and 4). The light-producing tissues (photocytes) for *P. pyralis* lie parallel to the cuticle, and in cross section (Figures 5 and 6) one can immediately see the very regular shape of the flower-like rosettes of the photocytes (Figure 5, white arrow, and Figure 6). This encompasses the entire bed of tissue from side to side. Each rosette surrounds a tracheal tube,

which feeds air from outside the body (containing oxygen and nitrogen—both important to the proper function of the photocytes) into the photocytes. The tracheal tubes appear to be lined with cilia, which would be very effective in moving fluids to the photocytes; however, we now know these tubes are filled with air, not liquid (Persijn and Harren, 2006). Furthermore, just below the photocyte tissues exists a layer of specialized tissues that stains differently (Figure 5, black



Figure 3. SEM close-up image of terminal end of *Photinus* abdomen showing end sternites under which light emitting tissues lie (black arrows). Dotted scale bar = 1.20 mm.

arrow) and, in fact, is a reflecting layer of cells that increases the transmission of light through the insect's cuticle (Buck, 1948, p. 404).

This anatomy is usually markedly different for other fireflies:

Firefly light organs show an astonishing diversity of structure and can be classified in a number of arbitrary ways (Buck, 1948, p. 400).

What is more, so much diversity exists that Buck (1948) states, "The luminous organs of the firefly are so diverse that the only generalizations pos-

sible are that they are close to the body surface behind a window of translucent cuticle, and are usually different in male, female and larva" (p. 399). This is not what would be expected on the basis of an evolutionary descent and relatedness among all of these animals—which are all still fireflies!

On an interesting note, a comparison was made between the fat bodies of this beetle and of another Coleoptera beetle, *Brachinus*, also known as the bombardier beetle, and discussed in a previous work (Armitage, 1993). As can



Figure 4. High magnification SEM image of the outer surface of the firefly exoskeleton. Scale bar = 60 micrometers. Although this exoskeleton appears to be opaque, it is translucent to the light produced underneath it.

be seen in Figures 7 and 8, the lipid droplets in *Brachinus* are massive and more numerous than those in *Photinus* at the same magnification. In view of the fact that form follows function and that a Master Designer was involved in the production of these structures, these differences make sense. It is smart design to put larger and more plentiful energy reserves into the fat body of an insect that relies on such energy to survive instantaneous attacks from lethal predators than the energy demands of another fat body designed to supply intermittent energy for low intensity light used in mating.

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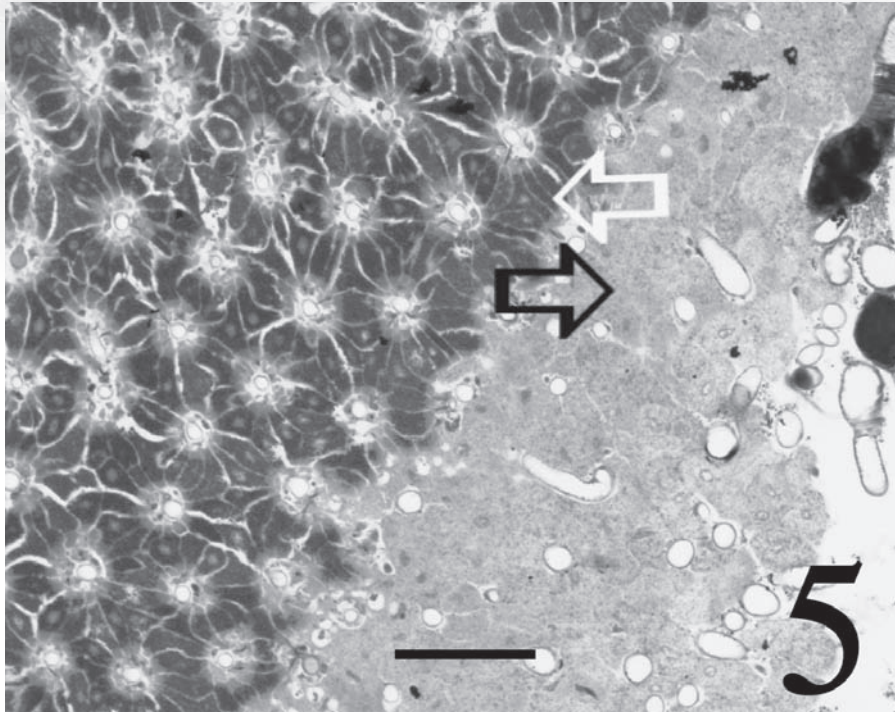


Figure 5. High magnification light micrograph of the thin sectioned light-emitting tissues of *Photinus pyralis* (white arrow). Note the recurring pattern of “leaf petal” rosettes surrounding the central holes through which atmospheric gases are transported to the tissues. The section to the right (black arrow) is basal tissue, called a reflective layer, that reflects light. Scale bar = 120 micrometers.

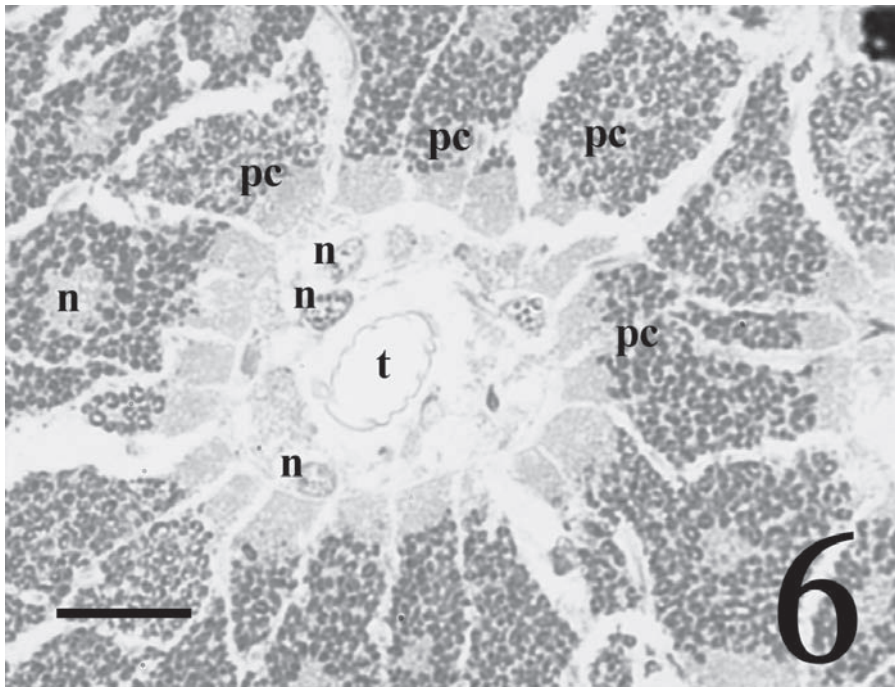


Figure 6. Very high magnification light micrograph of one “rosette” of light-emitting tissue. Scale bar = 15 micrometers. Labeled structures include nucleus (n), photocyte (pc), and tracheole, or opening for air exchange (t).

Thanks also to Dr. Dave DeWitt of Liberty University for collecting specimens for this project. *Solo Deo Gloria.*

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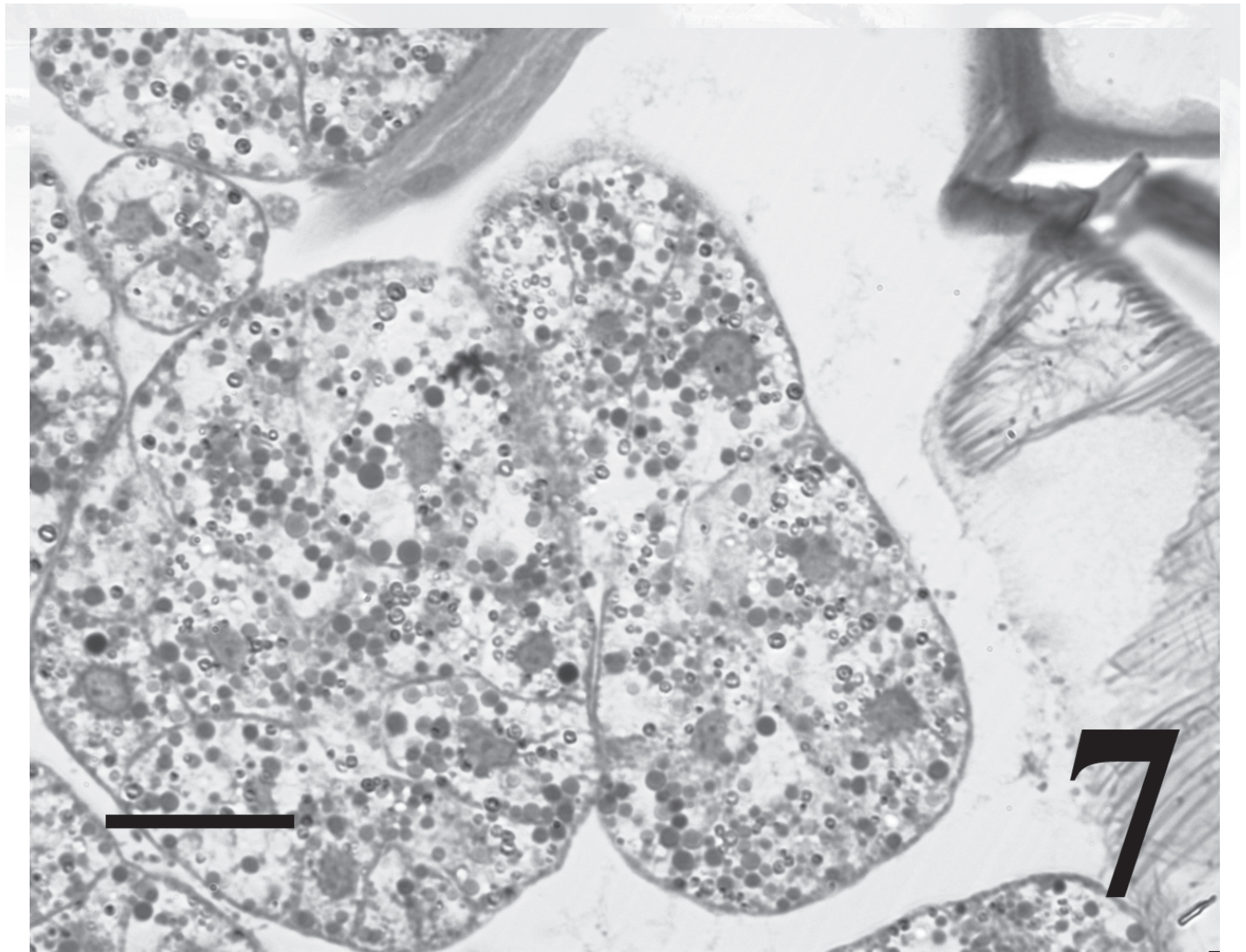


Figure 7. Very high magnification light micrograph of the fat cells of *Photinus pyralis*. Scale bar = 10 micrometers. Note small grey globules of lipids (an oil used for energy).

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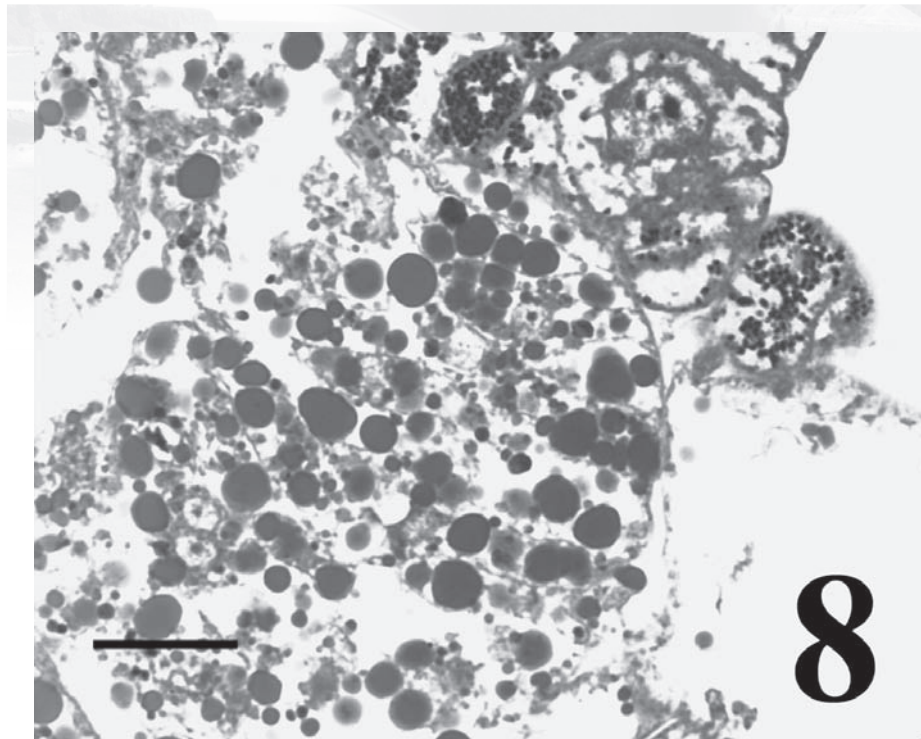


Figure 8. Very high magnification light micrograph of the fat cells of *Brachinus* sp. (bombardier beetle). Scale bar = 10 micrometers. Note grey globules of lipids are larger for the bombardier than for the firefly. The bombardier uses fat reserves to generate large amounts of energy for self-defense, thus the larger lipid globules are a design feature for rapid energy production.

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The Brain of *Archaeopteryx* and the Flight Muscles of *Protoavis*

A 3-D CAT scan of *Archaeopteryx* reveals that it had a large brain with the optic lobes of a modern bird. It is not the brain of a dinosaur (Hecht, 2004), although dinosaurs are believed by many to have been the ancestors of birds. The inner ear of *Archaeopteryx* also resembled that of a modern bird.

A fossil known as *Protoavis*, which is thought to have lived some 75 million years before *Archaeopteryx*, also had a number of advanced avian features. Along with a bird-like wishbone, *Protoavis* had a keel for flight. There are only two modes of flight known throughout time. One uses a patch of skin or membrane, as in the case of bats and

flying reptiles, and the other mode of flight involves feathers. While *Protoavis* shows no evidence of flying with a skin or membrane, flight muscle attachment sites appear reasonably well established, which leaves feathers as its likely flight mechanism (Brown, 1987; Calais and Duffett, 1988).

Protoavis is so much "older" than *Archaeopteryx* that it would have existed long before all the dinosaurs that are supposed to have been the ancestors of *Archaeopteryx*. This indicates that birds existed in the strata "before" their dinosaur forebears, a scenario that completely invalidates the theory of bird evolution.

Acknowledgments

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Dependency of Radioisotope Age on Geologic History

A radioisotope parent/daughter ratio that has been established at the point of Creation, or represents modification by subsequent radioactivity, may be significantly altered by removal of either parent or daughter element in a geologic process (Rotta, 2006). Removal may be by diffusion during an epoch of elevated temperature, or by solution associated with epochal penetration by water. To elaborate the possibilities for radioisotope age modification by geologic processes, we can give consideration to two mineral samples, A and B, with radioisotope age characteristics T_A and T_B such that $T_A > T_B$ and represent two independent parent/daughter ratios (e.g., K/Ar vs Rb/Sr. See Figure 1.).

Reduction of the parent element without compensating change in the associated daughter will alter the indicated radioisotope age, increasing T_A to T_{A-Pa} , or T_B to T_{B-Pb} . Correspondingly, reduction of the daughter element will decrease T_A to T_{A-Da} , or T_B to T_{B-Db} .

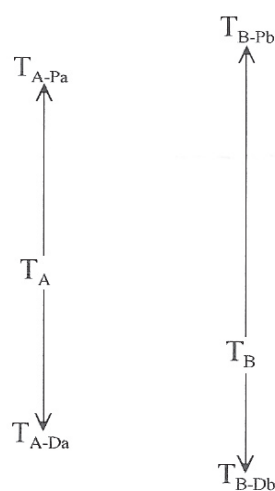


Figure 1. Radioisotope Age Relationships. Initial ages $T_A > T_B$ for two independent isotope pairs. Ages T_A - and T_B - after a geologic episode in which there was partial removal of parent, P, or daughter, D, element. Reduction of parent/daughter increases/reduces the designated radioisotope age.

Suppose the radioisotope age indications were initially in agreement, $T_A = T_B = T_C$, rather than $T_A > T_B$, as indicated in Figure 1. There is remote possibility for change even to agreement at T_x , a value that has no significance with respect to radioactivity. The only significance of such T_x is that it is $> T_C$ for loss of parent element, and $< T_C$ for loss of daughter.

To reach congruence for initially incongruent samples by loss of parent, as depicted in Figure 1 ($T_{A-Pa} = T_{B-Pb}$), requires a greater loss effect by the sample with the younger age of the two. Loss of daughter from initially incongruent samples may produce congruence if there is either a greater loss effect by the sample with the greater age, or an appropriately lesser loss effect by the sample with the initially lesser age. We may suspect greater likelihood for congruent results from daughter loss than from parent loss. If an analysis of data brings suspicion of fortuitous congruence, that suspicion would be strengthened by accompanying evidence for loss of daughter element.

While agreement between two independent radioisotope age determinations may suggest a geologic incident or epoch, the greater the number in such agreement the stronger the focus will be on explanation by a shared period of radioactive decay, in preference to random agreement of the consequences of change in chemical composition. One of the best examples of three-determination congruence that may be cited is 1.99 ± 3 Sm-Nd, 1.98 ± 6 Pb-Pb, 1.97 ± 2 million-year age from the Baltic Shield (Puchtel et al., 1999). There has been one publication of six-determination congruence at 3.84 billion-years (Misawa et al., 1993).

Conclusions

A characteristic radioisotope age may be either increased or reduced by geologic processes that partially remove either parent or daughter member of an isotope

pair. Total removal of parent produces infinite radioisotope age; total removal of daughter defines zero age. At any age between those extremes there is a possibility for a geologic episode causing reversal of the relation of older to younger age, or for producing a fortuitous congruence that does not have a direct meaning with respect to real time. Parent and daughter removal could leave the parent/daughter ratio essentially undisturbed, and not produce a significant change in radioisotope age. There is no way to make a direct determination of whether congruence of radioisotope age determinations by two different isotope pairs is merely the chance consequence of parent or daughter atom removal in a geologic process, but consideration of the relative likelihood for removal of the associated elements by diffusion (heat) or solution (interaction with water) may be necessary for development of a satisfactory interpretation of some radioisotope age data.

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— R. H. Brown

Instructions to Authors

Submission

Submit an original plus two copies of each manuscript to the editor of the *Creation Research Society Quarterly* (see the inside front cover for address). Concurrent submission of an electronic version (Word, WordPerfect, or Rich Text Format) of the manuscript text and graphics is also encouraged. The manuscript and graphics will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. Manuscripts containing more than 30 pages are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

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Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

———. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

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Creation Research Society

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2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.

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