# EDITORIAL

## WHAT IS HAPPENING TO THE PHILOSOPHY OF SCIENCE?

Two centuries ago the French mathematician-astronomer Pierre Simon de Laplace developed the nebular hypothesis which proposed that the solar system originated by condensation from vaporous matter. Laplace, who had become famous, decided to present a copy of one of his books to the Emperor Napoleon, who had been informed in advance that the book contained no mention of God. The emperor asked Laplace why he had never even mentioned the Creator of the universe in his book. Laplace replied tersely "that he had no need of that particular hypothesis".[1]

Explanations of origins which excluded God were not new with Laplace. They had been suggested earlier by a number of philosophers and gained further acceptance when naturalistic scientific explanations (those which exclude the supernatural) gained popularity.

The tendency in science towards self-sufficiency as illustrated by Laplace's comment is important in determining the intrinsic value of scientific conclusions. The much-respected scientific philosopher Michael Polanyi[2] makes the following comments in addressing the origin of the problem:

> *This is where I see the trouble, where a deep-seated disturbance between science and all other culture appears to lie. I believe that this disturbance was inherent originally in the liberating impact of modern science on medieval thought and has only later turned pathological.*
>
> *Science rebelled against authority. It rejected deduction [reasoning based on premises] from first causes in favour of empirical [sense perception] generalizations. Its ultimate ideal was a mechanistic theory of the universe....*

One of the important mechanistic explanations has been the theory of evolution.

In the early part of this century science was considered by many as the authoritative source of information with almost limitless potential. These views were strengthened by the work of the group called the Vienna Circle, which consisted of philosophers, scientists and mathematicians who met regularly in Vienna, Austria, in the 1920s and 1930s. A related group met in Berlin. World War II brought on the demise of these groups.

The Vienna Circle advocated logical empiricism, also referred to as scientific empiricism. This concept affirms sense-experience as the basis for knowledge. The Circle also emphasized positivism which in its most extreme form stipulates that the only valid kind of knowledge is scientific. Their famous "manifesto" stated:

> *We are struggling for order and clarity. We reject all hazy perspectives and bottomless depths. For in science there are no depths; everything in it is on the surface.*[3]

Implied in this statement is the concept that metaphysics (the more abstruse aspects of philosophy, such as ultimate beginnings, religion, ethics, and esthetics) is unacceptable. Faith in the methodological perfection of science developed, and attempts were made to make all meaningful concepts fit into physical coordinates such as time and space. Physico-mathematical information was elevated to the level of absolute truth.

Logical empiricism dominated in scientific thinking for many decades to well past the middle of the twentieth century, even though some disturbing, challenging developments had made their appearance earlier. In 1927 the German physicist Werner Heisenberg enunciated the principle of uncertainty which denied the possibility of absolute knowledge of certain physical phenomena. For example, the greater the accuracy in measuring the position of an electron, the less accurately one is able to measure its speed simultaneously. The principle evoked much discussion regarding the subjective nature of what is assumed to be knowledge.

Mathematics and logic were also in trouble. In 1931 the mathematician Kurt Gödel at the University of Vienna published a short and unwelcomed paper which showed that any system large enough to be interesting should have some unprovable elements. Several other scholars developed theorems along the same line. These theorems, known as the limitative theorems, dashed any hopes of finding a logical fool-proof system of truth. Even mathematics, which was free of the limits of observations and other restrictions of science, was found to lack in certainty. It turns out that belief in the consistency of mathematics is a matter of faith and not of logical proof. Likewise no broad scientific statement can be free of uncertainties. This all ran counter to the hopes of the Vienna Circle.

Others addressed more directly the apparent unwarranted respect for science. One of the most vocal critics has been Theodore Roszak, who objected to the reductionist (oversimplification) tendencies of scientific interpretations. In particular he criticized science for oversimplifying reality and for "the turning of people and nature into more, worthless things."[4] According to him, man is more than a mere machine.

The noted, and sometimes controversial, philosopher of science, Paul Feyerabend, may be science's most vocal critic.[5] He considers science to be an anarchist movement. He points out that since there is no one scientific method, hence no consistency in science, the success of science must depend not only on logic but on persuasion, propaganda, subterfuge, and rhetoric. Due to its subjectivity, he states, science should be given equal

status with astrology and witchcraft. Bemoaning the authority and respect generally given to science and scientists he states, "... the most stupid procedures and the most laughable results in their domain are surrounded with an aura of excellence. It is time to cut them down in size, and to give them a more modest position in society."[6]

All of this and much more contributed to the demise of logical empiricism. The eminent scientific philosopher Karl Popper[7] points out.

> *The old scientific ideal of episteme — of absolutely certain, demonstrable knowledge — has proved to be an idol. The demand for scientific objectivity makes it inevitable that every scientific statement must remain tentative for ever. It may indeed be corroborated, but every corroboration is relative to other statements which, again, are tentative. Only in our subjective experiences of conviction, in our subjective faith, can we be 'absolutely certain' (*p 280).
>
> *Science never pursues the illusory aim of making its answers final, or even probable* (p 281).

On the other hand, Popper himself has helped science regain some confidence by suggesting a new approach to scientific investigation that has gained a significant degree of acceptance. He proposes that science should not establish truth by induction or confirmation of consequences or the refutation of rival concepts, but by the more severe empirical (sense experience) tests of trying to falsify the hypothesis itself, and a hypothesis should be empirically falsifiable to be considered scientific. Often it is not recognized in scientific endeavors that this concept tends to narrow science to a rather limited segment of reality.

Another blow to the objectivity of science has come from the pen of historian-philosopher Thomas Kuhn who in his book *The Structure of Scientific Revolutions* [8] pointed out that normal science is the refining of broadly accepted concepts called paradigms. Examples would be alchemy, uniformitarianism, or evolution. Most scientific data are fitted into a paradigm by varying modes of explanation. The paradigm itself is not tested, since it is believed to be true. Occasionally science has a change in paradigm, and this is called a scientific revolution. During a period of normal science a scientist must fit his data into the accepted paradigm or become discredited by the scientific community. Kuhn did not endear himself to scientists when he described the transfer from one paradigm to another as being a "conversion experience" (p 151), and he emphasized that a new paradigm may not be closer to truth than the rejected one. He states: "We may, to be more precise, have to relinquish the notion, explicit or implicit, that changes of paradigm carry scientists and those who learn from them closer and closer to the truth" (p 170).

Kuhn's concept, first published in 1962, raised many questions and engendered a kind of revolution itself. Up to that time philosophy in general had been dominated by the philosophy of science. This prime role has been declining, and the philosophy of science has been labelled as being in a "crisis stage" due to a loss of confidence in objectivity and also to the collapse of logical empiricism, which has been labelled as "dead."[9]

Science is now being perceived more as a human activity, and the contrast between so-called objective truth and metaphysics is considered a "relic of a bygone philosophy of science."[10] For instance, the question is now being raised as to why cosmology should not be reinstated to its former status as the combined realm of science, philosophy and religion. Science is now perceived more as an activity with sociological dimensions. The focus is more on the factors that determine the origin and formulation of scientific questions than on the answers to these questions; and complex, holistic (broad-approach) methods are replacing reductionistic (simplifying) ones. The scientific philosopher Ronald Giere[11] has made a radical proposal that would have struck the pre-Kuhnian logical empiricists as "bizarre if not absurd."[12] He suggests that the philosophy of science itself, which once held a super-eminent place, should be subject to testing by evidence as is required of any other model. He especially emphasizes historical data as significant in evaluation.

The loss of confidence in science is, of course, of major concern to some scientists; unfortunately, many are unaware of the changes occurring in their philosophy. Nevertheless, the primacy science once held in intellectual pursuits is being severely challenged. Two British scientists in expressing their concern state: "Having lost their monopoly in the production of knowledge, scientists have also lost their privileged status in society."[13] These authors bemoan the resultant loss of funding for science and the ascent of competing concepts such as creation. They are concerned that by releasing a monopoly on truth, science may be reduced to a pointless game.

No one knows where the philosophy of science is going next. In the last few years it has moved well beyond Kuhn's original sociological suggestions. It appears to be going in diverse directions.[14] There are those philosophers who are only presenting old wine in new bottles, while others have made a complete reversal from empirical (verification by sense experience) concepts to more subjective bases. These are interesting intellectual times.

In summary, we can note that the philosophy of science has abandoned the view that science can give us perfect knowledge. Other factors (sociological, psychological, etc.) are considered to be important determiners of scientific questions and the resultant answers. This has resulted in a notable

anti-scientific reaction. While scientism (science as a kind of religion) is still very alive in limited circles, science no longer commands the high respect it had during the first two-thirds of this century.

On the basis of the above there are those who would tend to reject all scientific information as simplistic, biased, and restricted. Such views seem unwarranted. While the adjustment that the philosophy of science has had to take in recent decades is salutary, we must not forget that science is a marvelous enterprise which no one can deny has an impressive record of successes, especially in the naturalistic realm. The limitations and problems inherent to science and its philosophy should not be used as excuses to deny the value of science in its proper sphere. On the other hand, the simplistic worship of science seems to be likewise unwarranted. In too many instances science has gone wrong in trying to explain everything within its own limited system. Science is a great good in bringing us an abundance of new information, but to blindly follow it and follow it alone is not only bad; it is very bad.

Ariel A. Roth

## REFERENCES AND NOTES


1. Quoted in: Dampier WC. 1949. A history of science and its relations with philosophy and religion. 4th ed. rev. Cambridge: Cambridge University Press, p 181.
2. Polanyi M. 1969. Knowing and being. Chicago: The University of Chicago Press, p 41.
3. Quoted in: Zycinski JM. 1988. The structure of the metascientific revolution: an essay on the growth of modern science. Tucson, AZ: Pachart Publishing House, p 49.
4. Roszak T. 1972. Where the wasteland ends. Garden City, NY: Doubleday & Co., p 252.
5. Feyerabend P. 1988. Against method. Rev. ed. London and NY: Verso.
6. Feyerabend P. 1975. Against method. London: New Left Books, p 304.
7. Popper KR. 1959. The logic of scientific discovery. NY: Basic Books.
8. Kuhn TS. 1970. The structure of scientific revolutions. 2nd ed. enl. Chicago: The University of Chicago Press.
9. Blackwell RJ. 1981. A new direction in the philosophy of science. The Modern Schoolman 59:55-59. Also see Reference 12.
10. Zycinski JM. 1988. The structure of the metascientific revolution: an essay on the growth of modern science. Tucson, AZ: Pachart Publishing House, p 178.
11. Giere RN. 1984. Toward a unified theory of science. In: Cushing JT, Delaney C, Gutting GM, editors. Science and Reality: Recent Work in the Philosophy of Science. Notre Dame, IN: University of Notre Dame Press, p 5-31.
12. Durbin PT. 1986. Ferment in philosophy of science: a review discussion. Thomist 50:690-700.
13. Theocharis T, Psimopoulos M. 1987. Where science has gone wrong. Nature 329:595-598.
14. See Reference 12.

# ARTICLES

## A POST-FLOOD ICE-AGE MODEL CAN ACCOUNT FOR QUATERNARY FEATURES

Michael J. Oard
*National Weather Service*
*Great Falls,Montana*

**WHAT THIS ARTICLE IS ABOUT**

*A model of an ice age caused by the Genesis flood is summarized. It proposes solutions to a number of ice-age problems. A rough estimate of the time to reach glacial maximum and the melting time is presented. This model can account for the Greenland and Antarctica ice sheets.*

### INTRODUCTION

Many phenomena that have not yet been adequately explained occurred in the latest period of geologic time. The Pleistocene is part of post-flood time in a creation-flood paradigm. This period was dominated by an ice age at mid and high latitudes. Thus, an adequate ice-age model must be able to explain these phenomena.

One Quaternary puzzle is the widespread evidence for large lakes and rivers in currently arid and semi-mid regions around the world. This is explained as being the result of a wet climate during a pluvial (rainy) period. For example, in the southwestern United States Lake Bonneville was 17 times larger and 285 m deeper than its shriveled remnant, Great Salt Lake. Six times the current runoff likely was needed to maintain Lake Bonneville in a cool ice-age climate (Smith & Street-Perrott 1983).

Another major problem is the extinction of the woolly mammoth in Siberia and Alaska. Many thousands, possibly millions, of them lived in this region, which today is characterized by bitterly cold winters and permafrost which produces massive summer swamps. Little food is available for large herds of mammals. For the mammoths and many other types of mammals to have lived there, it seems likely that the climate was much warmer and without permafrost. A rapid and permanent climatic cooling may have been responsible for the extinction of these animals.

A third important ice-age problem is the widespread evidence of cold-tolerant animals living side by side with warmth-loving animals

(Martin & Klein 1984). For example, reindeer fossils have been found with hippopotamus fossils in the Thames River valley of southern England (Grayson 1984, p 16). Evidently, the hippopotamus ranged into northern England, France, and Germany during early post-flood time (Sutcliffe 1985, p 24). Then at the end of the ice age, when most scientists believe the climate to have been warming, many large mammals became extinct — about five times as many as died out over the combined twenty to thirty presumed previous glaciations.

During deglaciation large river valley meanders were cut by runoff from the melting ice sheets. Water volumes about 60 times the present flow are indicated (Dury 1975). This evidence suggests catastrophic melting.

These and other questions can be solved by a model for a post-flood ice age. Such a model has been proposed (Oard in press, b). A brief summary of this model and an estimate of the duration of the ice age have been published elsewhere (Oard 1979, 1980, 1987). In this article I will summarize the model, giving particular attention to the time required to develop and melt the ice sheets. Throughout I will suggest solutions to ice-age questions.

## A POST-FLOOD ICE-AGE MODEL

The requirement for an ice age is a combination of much cooler summers and greater snowfall at mid and high latitudes (Fletcher 1968, p 93). The snow cover during the first year must last through the summer, and sufficient moisture must be added year by year to continue growth. If summers are very cold, a modest snowfall increase over the average can be adequate; if the summer cooling is small, a many-fold increase would be necessary. This presents a major problem for conventional models of the ice age in that cooler air is less able to hold moisture (Byers 1959, p 161). The lack of moisture for an ice age is perhaps the reason why more than 60 theories for the ice age have been proposed (Eriksson 1968, p 68). Nearly all these theories have serious scientific problems, as stated by Charlesworth (1957, II:1532) over 30 years ago:

> *Pleistocene phenomena have produced an absolute riot of theories ranging 'from the remotely possible to the mutually contradictory and the palpably inadequate.'*

This statement was even more true ten years ago, according to John (1979, p 57), and the currently popular astronomical theory of the ice age is no exception (Oard 1984 a, b, 1985).

Using a computerized energy-balance model, Williams (1979) found that with a snow depth given by twice the present cold-season snowfall, a 10-12ºC average summer temperature drop was required for a perennial snow cover in northeast Canada. The basis for this conclusion is that melting of snow is controlled more by solar radiation, which is abundant at higher latitudes in summer, than by air temperature (Paterson 1981, p 313). Researchers have been focusing too much on the latter. At the above temperature change, the air would hold 60% less water vapor at saturation. This is a very large decrease in moisture, which was not taken into account by Williams, whose model already slightly overestimated the summer snow cover. It is evident that if a long-age mechanism for summer cooling could be found, the precipitation likely would fall far short of the requirement for an ice age. The need for an adequate cooling mechanism which also provides abundant moisture is one of the main difficulties in developing a successful ice-age model on a conventional time scale. The model presented in this paper proposes that the requirements for an ice age can be met in the climatic upheaval following the Genesis flood.

The flood was a tremendous tectonic and volcanic event. Layers of volcanic ash mixed within sedimentary rocks and large basaltic lava flows attest to extensive flood volcanism. Over 50,000 volcanoes are estimated on land and on the bottom of the ocean. Many of these likely formed during the flood. At the end of the flood a large amount of volcanic dust and aerosols would presumably have been trapped in the upper atmosphere. This would cause strong surface cooling over continental areas by reflecting a significant quantity of solar radiation back to space, while infrared radiation continued to escape. Once a snow cover was established, an increased portion of sunlight would be reflected back to space, reinforcing the cooling. Cooling of the atmosphere above a snow cover is especially effective over barren land, as most land would be immediately after the flood. For instance, a fresh snow cover over barren land will reflect 80% of the sunlight back to space under clear skies, while a snow-covered forest only reflects back 25%. Bare soil under clear skies reflects 10-25% of the sunlight back to space. Greater concentration of atmospheric moisture at higher latitude causes more low cloudiness, which is now known to cool the surface (Ramanathan et al. 1989).

The vast shroud of volcanic dust and aerosols resulting from the flood upheavals would settle out of the atmosphere within a few years,

but the planet likely would not settle down to geophysical equilibrium for hundreds of years. Further volcanism at a variable but gradually decreasing rate would be expected, continuing the cool summer temperatures over land. Surficial sediments provide a large amount of evidence for much more ice-age volcanism than there is at present. Charlesworth (1957, II:601-603) states that signs of ice-age volcanism are visible over the whole earth. This evidence is based on numerous ash layers, sometimes covering large areas. In the western United States alone, at least 68 large ash falls have been identified during the ice age (Izett 1981). The ash from one large eruption on New Zealand covered $1\times10^7$ km$^2$ of the Southern Hemisphere, and probably blocked out practically all sunlight over the entire earth (Froggatt et al. 1986). Many of the ice-age volcanic eruptions were much larger than those which have occurred over the past 200 years. Modern large eruptions, such as Tambora and Krakatoa, are not even expected to leave an ash layer that would survive conspicuously over large areas (Froggatt et al. 1986). Sulfur aerosols are believed to be the primary long-lasting cause of surface cooling, since volcanic dust can settle and be washed out of the atmosphere in a matter of months. Basalt lava flows, which are less explosive than such eruptions as Tambora and Krakatoa, are now considered to have been a major source of upper atmospheric sulfur aerosols in the past, especially since these milder eruptions contain ten times as much sulfur compounds as do the more explosive eruptions (Devine, Sigurdsson & Davis 1984).

Most scientists do not accept a volcanic cooling mechanism because of their greatly expanded time scale. Since glacial geologists believe each ice age lasted around 100,000 years (Imbrie & Imbrie 1979), volcanism. is seen as an insignificant factor. However, the possibility that high volcanic activity could initiate continental glaciation is acknowledged:

> *... volcanic explosions would need to be an order of magnitude more numerous than during the past 160 years to result in continental glaciation equivalent to the Wisconsin glacial episode* (Damon 1968, p 109).

The Wisconsin glacial episode is the last glaciation in the standard ice-age chronology. Bray (1976) has suggested that a period of high volcanism may indeed have triggered glaciation by causing cooler summers for a few years, which in turn resulted in an extensive summer snow cover. The snow cover then reinforced the initial cooling, and an ice age was started. Bray (1976) writes: “I suggest here that such a

[snow] survival could have resulted from one or several closely spaced massive volcanic ash eruptions."

The water for the flood is assumed to have come predominantly from the "fountains of the great deep" (Genesis 7:11). Enough water was added to the pre-flood oceans to cover all the mountains over the entire planet (Genesis 7:19). Although pre-flood mountains either were much lower than present ones (Psalm 104:5-9) or were lowered by tectonic activity, the added water was still substantial. The "fountains of the deep" imply water shooting high up into the air from cracks or fissures in the earth. This water must have been trapped in the crust of the earth and released under pressure. If we assume that this water came from deeper sources than our usual aquifers, it would be hot water, since the crust warms 30ºC per km of depth. The temperature of subterranean water today varies from the warm temperatures of hot springs to about 350ºC in geothermal vents along the mid-ocean ridges (Kerr 1987). Therefore, the ocean after the flood would be warm. How warm depends upon such variables as the amount and average temperature of the added water and the average temperature of the pre-flood ocean. The post-flood ocean could easily have been hot. But if the average temperature was much warmer than 30ºC, marine life as we know it now would have been seriously threatened. This suggests using 30ºC as a probable maximum temperature for the oceans immediately following the flood. Because the tectonic activity associated with the flood would mix the ocean water, a generally uniform ocean temperature from pole to pole and from the surface to the bottom would have resulted.

Oxygen isotope changes in foraminifera from ocean sediments indicate that the bottom water temperature was relatively warm in the past, compared to the present 4ºC. This evidence comes from pre-Quaternary sediments (Kennett 1982, p 717). For example, Paleocene ocean bottom temperatures are calculated to have been as warm as 13ºC. Most creationists would consider pre-Quaternary sediments to be flood deposits. This is probably correct for indurated sediments. Unconsolidated ocean sediments are mostly dated by index microfossils, especially foraminifera. Pre-Quaternary microfossils could easily have lived during the ice age. If all biogenic sediments on the ocean floor, except the most recent, were laid down in the waning stages of the Genesis flood and during the ice age, the trend in oxygen isotope changes in pre-Quaternary sediments, even if only crudely valid, would support a warmer ocean bottom at the beginning of the ice age.

The warm post-flood ocean provides the abundant moisture required for the ice age. The cooling mechanisms would have little effect on the ocean temperature until well into the ice age, due to the large heat capacity and circulation of the ocean. Evaporation rate is proportional to the ocean surface temperature. If all other variables remain constant, the evaporation rate at an ocean surface temperature of 30ºC is over three times greater than it is at 10ºC, and over seven times greater than it is at 0ºC. The mid- and high-latitude atmosphere especially would receive much more moisture than today. Evaporation also depends upon how dry and cold the air above the ocean is, and on how fast the wind blows. Consequently, evaporation would be strongest in the storm belt off the east coasts of North America (Bunker 1976) and Asia and off the coast of Antarctica, where cold and relatively dry air blows off the continent and over the warm water in the dry sectors of storms. In the ice-age era, the ocean circulation would continually replenish warm ocean water in these areas. This replacement would come from the deep ocean and from lower latitudes. At this time the Arctic Ocean would be not only ice free, but also quite warm! Large quantities of moisture, as well as heat, would be released into the polar atmosphere.

The average precipitation over mid- and high-latitude continents would have been at least three times the current rate. This factor and the Genesis flood would explain the evidence of a pluvial period in currently arid and semi-arid areas. Large basins, such as those found in the southwestern United States, would have been filled with water at the end of the flood. After the flood, higher precipitation during the ice age would have partially maintained most of these large lakes in currently arid areas and provided adequate moisture for larger streams and rivers. The evidence that a much wetter climate in present-day arid and semi-arid areas occurred after the flood is provided by the existence of large extinct drainage networks in the Sahara Desert and the discovery of remains of such animals as the elephant, hippopotamus, crocodile, giraffe, antelope, and rhinoceros along these now-dry rivers (McCauley et al. 1982, Pachur & Kröpelin 1987).

Many areas which are close to the warm water, such as northern Siberia and Alaska, would have cool summers and mild winters with high precipitation. Warmer ice-age winters for these regions can be surmised from a climate simulation without the Arctic ice cap. Keeping all other variables the same as today, but removing the Arctic ice cap and maintaining the surface temperature at freezing, Newson (1973)

discovered winter temperatures would warm 20-40ºC over the Arctic Ocean and 10-20ºC over northern Siberia and Alaska. Precipitation would also have been much heavier than today. Since the Arctic Ocean immediately after the flood would be much warmer than freezing, ice-age temperatures would be significantly warmer than those reported by Newson. As a result of warmer, wetter winters, the woolly mammoth and other cold-tolerant mammals would find a favorable habitat in Siberia and Alaska during the ice age. A warm Arctic Ocean would explain the development of an ice dome in the normally very dry Keewatin area, northwest of Hudson Bay.

The storm tracks of today generally are associated with the strongest upper winds aloft — the jet stream — which are found in areas of strong horizontal temperature change. The storms and winds aloft are generally parallel to the isotherms with the cold air on the left facing downwind. In today's climate the strong horizontal temperature change is constantly shifting over mid and high latitudes. No one area receives an over-abundance of precipitation. But in the post-flood climate, the cooling mechanisms would operate continually to keep the mid- and high-latitude continents cool. When juxtaposed to warm oceans, these cool continents would cause the greatest temperature difference to remain stationary year-around, lying parallel to the shoreline of mid- and high-latitude continents. Due to the contrast between snow-covered and non-snow-covered land, another belt of large temperature difference would be found at the edge of developing ice sheets.

Westerly winds aloft blowing across the Himalaya and Rocky Mountains would reinforce the stationary thermal pattern over North America (Held 1983). However, this atmospheric phenomenon would tend to shift the major storm track farther offshore from eastern Asia. This factor plus the high mountains of eastern Asia, which would cause significant downslope warming and drying of west winds, and the warmth of the Arctic Ocean is probably the reason why 90% of the Northern Hemisphere ice developed around the Atlantic Ocean (Charlesworth 1957, II:1146). The lowlands of Alaska and eastern Asia were not glaciated — another difficulty for modeling based on a long time scale.

The unique meteorological features outlined above would result in the rapid establishment of a snow cover in favorable continental areas. It would be a snowblitz in that the ice age developed simultaneously over large areas (except for strips that were particularly close to warm ocean water). After accumulating to a significant depth, the snow would

turn to ice, either by pressure and recrystallization at depth, or from refreezing of meltwater. In the post-flood snowblitz, storms would often develop near the southeastern coast of the United States and move northeastward. These storms would be very much like present-day "northeasters" that wrack the eastern seaboard of the United States and southeast Canada every year. Northeasters cause crippling ice, heavy snow, and gale force winds with a resultant loss of life and more than a billion dollars in property damage each year (Dirks, Kuettner & Moore 1988). In a typical wintertime storm most of the precipitation falls in the colder air portion of the storm with a narrow band of showers along the cold front, south of the low pressure center. In the post-flood climate northeasters would have carried much more water vapor (due to the much warmer ocean), probably extended over a larger area, and developed much more frequently. In areas of great temperature contrast, one to three large storms and several small storms can develop in a week. To illustrate the potential for a snowblitz that turns into an ice age, I will conservatively assume that only one northeaster a week developed and moved up the east coast of North America. Let us assume that each storm dropped 5 cm water equivalent of snow over a broad area, which is only twice the amount of snow in modern northeasters. At this rate with no summer runoff, almost 3 m of ice would accumulate in a year. In 200 years the depth would reach 580 m over favorable areas of northeastern North America.

At the beginning of the ice age, snow and ice most likely extended well south into the central United States, since volcanic dust is particularly effective for cooling continental interiors. As volcanism diminished, increased penetration of sunshine would melt the ice sheet in the central United States, due to its southerly latitude. The ice margin would retreat to a more or less equilibrium position in the north-central United States. Heavy precipitation would then strongly erode the till left behind in the central United States. Clay, soil, and vegetation would form rapidly. On this basis, after the ice age the central United States would have an "ancient-looking" landscape, with the clay interpreted as the B-horizon of ancient soils.

## DISHARMONIOUS ASSOCIATIONS

Northwest Europe would have been dominated by warm onshore winds during the early part of the ice age. Rather warm winters in this area would not have inhibited the hippopotamus and other warmth-loving mammals from migrating as far as northern England. These

warmth-loving animals would mix with cold-tolerant animals forced to live south of the ice sheets. As a result the fossil remains of these animals would show a unique mix of seemingly incompatible animals in today's climate. This phenomenon is called disharmonious associations and was common during the ice age. Graham and Lundelius (1984, p 224) state:

> *Late Pleistocene communities were characterized by the coexistence of species that today are allopatric [not living in the same geographic area] and presumably ecologically incompatible....Disharmonious associations have been documented for late Pleistocene floras...,terrestrial invertebrates..., lower vertebrates..., birds..., and mammals....*

To account for hippopotamus fossils so far north it has been postulated that they lived during a warm "interglacial" period. However, we live in a warm interglacial period today, but today's interglacial climate is much too cold for hippopotamuses in northwest Europe. Furthermore, they are often found in the same sediment layer with animals that prefer a cold climate. Grayson (1984, p 16) states:

> *In the valley of the Thames* [southern England], *for instance, woolly mammoth, woolly rhinoceros, musk ox, reindeer (*Rangifer tarandus*), hippopotamus (*Hippopotamus amphibius*), and cave lion (*Felis leo spelaea*) had all been found by 1855 in stratigraphic contexts that seemed to indicate conternporaneity....*

To account for disharmonious associations some researchers postulate the mixing of fossils from glacial periods with those from "interglacial" periods. However, the postulated mixing is not a likely explanation for many disharmonious associations, because the associations are widespread and disappear in post-ice-age sediments. Graham and Lundelius (1984, p 224) write:

> *Most of the presently available evidence suggests that individual stratigraphic units are deposited in too short a time in relation to the rate of environmental change for this* [mixing of remains] *to be a likely cause....The widespread occurrence of disharmonious faunas in Pleistocene deposits also indicates that these associations were much too common to be spurious in all cases. In addition, if these associations are caused by sedimentary mixing, their frequency should be about the same for all time periods; but disharmonious associations are rare in Holocene [post-*

*ice age]faunas, and in stratified faunas they usually disappear at the Pleistocene/Holocene contact.*

Disharmonious associations during the ice age do not conform to expectations based on a conventional time scale, but can be explained by a mild post-flood ice age. An ice age in the standard framework is very cold. Computer simulations of the climate at ice-age maximum indicate temperatures on the order of 10ºC colder than today immediately south of the ice sheets (Manabe & Broccoli 1985). The climate was also drier at maximum. A colder, drier climate is also theoretically expected well before maximum glaciation, according to a system based on the conventional time scale. One would not expect warmth-loving, and even many cold-tolerant, animals and plants to survive relatively close to the ice sheets under the above conditions. Severe climatic stress should have occurred. However, great numbers of the animals existed, many of them large (McDonald 1984). Moreover, as the ice sheets melted, presumably from a warming climate that should have been more favorable to survival, many species became extinct — the opposite of what one would expect.

## THE LENGTH OF TIME

The duration of a post-flood ice age is of special concern to biblical creationists, since the ice age is cited as one example among many to support a long evolutionary time scale. The length of time for an ice age can be divided into two estimates: 1) the time necessary to reach glacial maximum, when the largest volume of ice was locked up into the ice sheets, and 2) the time required to melt the ice sheets (except, of course, for the ones in Antarctica and Greenland).

The time to reach maximum ice volume depends upon the unique controlling conditions. Volcanism would gradually wane with time, but the ice age would still continue if the snow that fell during the warmer half of the year remained fresh with a high reflectivity. This requires heavy snow, which, in turn, depends upon the ocean surface temperature in the precipitation region. In other words, as the ocean cooled, the available moisture would gradually diminish, and a time would come when decreasing snowfall and increasing sunshine would reverse glacial buildup. Therefore, the ocean surface temperature, which is proportional to the average temperature of the deep ocean, controls the length of time taken to reach glacial maximum. The average temperature of the ocean today is 4ºC. The ice-age maximum would certainly occur before

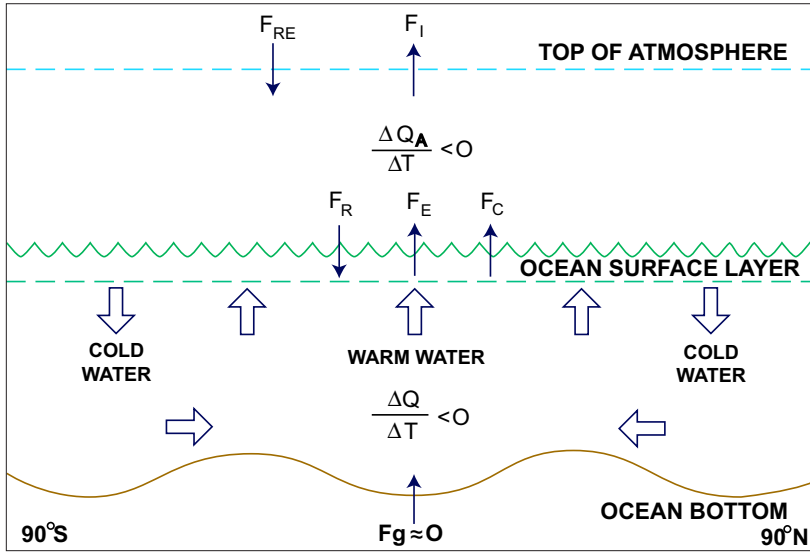



**FIGURE 1. Oceanic and atmospheric heat balance. $F_{RE}$ is the net solar radiation absorbed by the earth-atmosphere system, $F_I$ is the net infrared radiation escaping from the top of the atmosphere, $F_R$ is the net surface radiation, $F_E$ is the evaporative heat flux, $F_C$ is the conductive heat flux, $F_g$ is the geothermal heat, DQ/DT is the cooling rate of the ocean, $DQ_A/DT$ is the cooling rate of the atmosphere. The double arrows represent the general flow of water in the deep ocean. (Adapted from a drawing by David Oard.)**

the ocean cooled to this temperature. I will assume that the ice-age maximum occurred at a threshold ocean temperature of 10°C, or a 20°C drop in temperature from the end of the flood to glacial maximum. This change represents a net heat loss of $3.0\times10^{25}$ calories, most of which would occur in the form of latent heat of evaporation at mid and high latitudes (Bunker 1976, Budyko 1978).

The time to cool the ocean can be estimated from the heat balance equations for the ocean and the atmosphere and from reasonable assumptions of post-flood climatology. These heat balance equations relate the heat input and output to the change in heat content of the ocean and atmosphere. Figure 1 illustrates the components of the heat balance. The direction of the arrows indicates the heat flux.

The atmospheric heat balance must be included because latent and sensible heat ($F_E$ and $F_C$ in Figure 1) given off by the ocean heats the atmosphere. The large amount of heat involved in this process at mid

and high latitude would temper the cooling mechanisms (especially over and close to the ocean) so that early ice-age winters would be rather mild over continental areas. The heat liberated to the higher latitudes acts as a regulator or thermostat for the entire process. The main problem in estimating the time to reach glacial maximum is in finding appropriate post-flood values for the variables in the equations. Since post-flood climatology can be only generally presumed, I assigned each important variable in the equations a minimum and a maximum possible value. In this way the time to reach glacial maximum would be bracketed by extreme estimates (Oard in press, b). The most important variable in the equations is the reduction of solar radiation by clouds and by volcanic effluents. As a result, the estimated time to reach glacial maximum ranges from around 200 years to about 1700 years. A time of about 500 years is considered the most probable, based on the most reasonable values in the heat balance equations applied to the post-flood climate. These values are surprisingly short when compared to most estimates made by paleoclimatolgists, but they are derived from basic physics applied to a reasonable range of possible post-flood climatic conditions.

Soon after glacial maximum the mid-latitude ice sheets would begin melting rapidly. This is due to the fact that after volcanism and the precipitation decreased enough, much more solar radiation would be absorbed at the surface during summers in mid and high latitudes. During deglaciation winters at mid and high latitude would become much colder than they are today. The surface of the Arctic Ocean would freeze, possibly over a relatively few years, due to the addition of low-density meltwater that would float on the surface. Siberia and Alaska would quickly become significantly cooler than they are at present. Those animals that could not adjust to or migrate from the abrupt climatic change, such as the woolly mammoths, would become extinct (man in some cases hurrying this process). The end of the ice age would also be stressful for the animals that lived in other areas of the Northern Hemisphere. Some would become extinct or disappear from whole continents. The reason there were very few earlier extinctions is because there was likely only one ice age (Oard in press, a).

The volume of ice at maximum glaciation depends upon many variables, such as the total amount of water vapor available, how much of the water vapor falls as snow on the ice sheets, and the summer runoff. Summer runoff was neglected by assuming it was balanced by an increase in snow, due to re-evaporated moisture from non-glaciated

land. The total amount of water vapor depends upon the evaporation from warm mid- and high-latitude oceans and the transport of water vapor poleward from lower latitudes. Because of the many assumptions in estimating ice volume, a maximum and minimum estimate were made. Estimates of the average ice depth for the Northern Hemisphere ranged from 515-906 m, the most probable depth being about 700 m. The ice depth on Antarctica was estimated to range from 726-1673 , with a best estimate of about 1200 m. These values compare with typical estimates of 1700 m in the Northern Hemisphere and 1880 m over Antarctica (Flint 1971, p 84).

My estimates for the maximum ice volume are about one-half those obtained by conventional models, which are mostly based on analogy with the Antarctic ice sheet (Andrews 1982). There is substantial evidence that the largest ice sheet, the Laurentide ice sheet, was much thinner than the purported average of 1700 m. Field evidence from the interior region of this former ice sheet indicates that it was multi-domed and hence flatter than in the single-domed model (Shilts 1980; Hillaire-Marcel, Grant & Vincent 1980; Andrews 1982; Andrews, Clark & Stravers 1985). Based on the height of ice features on nunataks, the ice sheet was also very thin along much of the periphery (Mathews 1974; Clayton, Teller & Attig 1985; Beget 1986, 1987). The significance of this research is stated by Occhietti (1983): "These results change the concept of the Laurentide ice sheet radically. They imply notably a much smaller ice volume and complex margins."

The melting rate can be found from the surface heat balance equation over a snow or ice surface (Paterson 1981, p 299-320). The surface radiation balance causes about 60% of the ablation. The other 40% is the result of turbulent air and the condensation of water vapor onto the snow or ice surface. The magnitude of these two variables is proportional to the temperature and moisture content of the air immediately above the surface. The radiation balance was estimated for completely clear and completely cloudy skies and a maximum and minimum ice sheet solar reflectivity. The net ablation season was assumed to extend from May 1 to September 30. In calculating the heat loss from infrared radiation, I assumed average summer temperatures 10ºC cooler than at present along the periphery of the Laurentide ice sheet. Once the radiation balance was calculated, the other terms were simply assumed to be 40% of the ablation, since these terms are very difficult to estimate with precision.

The ablation rate ranged from 7.2-17.7 m/yr at the periphery; the best estimate was a conservative 10 m/yr. At this rate the peripheral ice would disappear in less than 100 years (Oard 1987). This melting rate is close to that estimated for the snouts of some Norwegian, Alaskan, and Icelandic glaciers (Sugden & John 1976, p 39). Hughes (1986) calculated a 55 m/yr ablation rate for the fast-moving Jakobshanvs Glacier on West Greenland. This high rate was due to several positive feedback mechanisms, which would also operate in some areas of the post-flood ice sheets. The interior area of the Laurentide ice sheet would melt more slowly than ice at the periphery. With the thin ice over interior areas in the model I am presenting, the interior of the ice sheet would likely disappear in less than 200 years. Consequently the total time for the post-flood ice age is reasonably on the order of 700 years (500 + 200).

The draining waters from the melting ice sheets would swell the rivers with water, causing large river meanders. These meanders have left geologic features (Dury 1976) which provide additional support for a catastrophic ice-age model. Large volumes of sediment carried down the rivers would create a complex sequence of river valley sedimentation and erosion, resulting in multiple terraces. These terraces can form rapidly, as has been shown on a smaller-scale in a different, but applicable context (Schumm 1977, p 214-221).

## GREENLAND AND ANTARCTICA ICE SHEETS

A post-flood ice age and the present climate can account for the ice sheets on Greenland and Antarctica. At the beginning of the ice age East Antarctica would have been a generally flat plain above sea level (Bentley 1965, p 263). Snow and ice would have accumulated rapidly on East Antarctica, since it was surrounded by warm water, and intense moist storms would circulate around it. Greenland and West Antarctica likely had only mountain ice caps at the beginning. The land below the Greenland ice sheet is a low-level plain punctuated by mountains (Fristrup 1966, p 237-248). Greenland would have been surrounded by warm water and probably was not large enough to establish a sizeable pool of cool air in the summer. However, during the progression of the ice age as the oceans gradually cooled, mountain ice caps would descend to lower elevations and coalesce into the Greenland ice sheet. Before the ice age, West Antarctica consisted of several mountain ranges surrounded by fairly deep ocean water (Bentley 1965, p 267). Mountain ice caps probably would not coalesce into the West Antarctica ice sheet until well within the ice age.

At maximum glaciation Antarctica would average about 1200 m of ice (see previous section). East Antarctica would have received more than this amount and West Antarctica significantly less. Greenland could have had greater than the average ice depth of 700 m for the Northern Hemisphere, since it was close to a main storm track and surrounded by warm water. During early deglaciation of the Laurentide and Scandinavian ice sheets, the ocean temperature would still have been relatively warm. As the temperature fell from 10ºC to 4ºC, snowfall would have been significantly heavier on the Greenland and Antarctica ice sheets than at present. Because of its high latitude (60-83º), high elevation and heavy snow, the Greenland ice sheet would not have melted with the other Northern Hemisphere ice sheets. The Greenland and Antarctica ice sheets could have grown several hundred meters thicker during continental deglaciation.

Even in the present climate these ice sheets would have continued to grow slowly until equilibrium was reached. The current water equivalent precipitation over Antarctica averages 17 cm/yr, but is much higher at the periphery than over the interior, which receives less than 5 cm annually (Paterson 1981, p 56). If the ice age ended 3500 years ago, Antarctica could have collected another 600 m of ice since that time, more at the periphery and very little in the interior of the East Antarctica ice sheet. Currently, Greenland accumulates a yearly average of 15 cm/yr in the north and more than 90 cm/yr in the south with an average of 30 cm/yr (Fristrup 1966, p 234). Since the end of the ice age an additional 1050 m of ice could have accumulated. Therefore, the amount of ice now observed on Greenland and Antarctica can be explained by a post-flood rapid ice age, followed by a climate similar to the present.

Data from ice cores suggest these ice sheets accumulated over much greater time than shown above. However, the dating of these ice cores has been mainly accomplished by curve matching of ice core oxygen isotopes to the oxygen isotope record in deep-sea cores (Dansgaard et al. 1971; Bradley 1985, p 152-153). Furthermore, equilibrium between accumulation and ablation is assumed for at least the entire Pleistocene period. Equilibrium assumes that the Greenland and Antarctica ice sheets built up before the Pleistocene, and the ice sheets have been flowing throughout that time. Consequently, the long time scale is automatically built in (Bradley 1985, p 147-150).

The upper half of the Greenland ice cores is probably dated accurately by counting annual layers. (The accumulation rate on Antarctica is too low to use this method.) For instance, the top 1000 m of the 2035 m Dye 3 core in central Greenland represents about 2500 years (Dansgaard et al. 1982). The bottom 5%-10% of the long cores supposedly represents about 90% or more of the total time interval based on inexact glacier flow models that assume equilibrium. The middle and most of the lower portion of these cores are within the transition between counting annual layers and dating by glacial flow models. The dates assigned to this layer will be interpolated between the bottom and the top, and thus depend upon the assumed age of the ice sheet.

## DISCUSSION

I have presented a general outline of a post-flood ice-age model and have indicated how it can explain many of the unusual phenomena of the ice-age period. I have especially emphasized that the ice age would be rapid. More details and possible explanations for other ice-age problems will be presented separately (Oard in press, b). Not all questions have been solved, and not all challenges to the short-time scale of the ice age have been addressed. We must remember, however, that the standard ice-age model, like any alternative model, is built on many assumptions, and data often are simply fitted into the popular model of the time. Bowen (1978, p 7) states: "Indeed it could be said that force-fitting of the pieces into preconceived pigeon-holed classifications is what is almost a way of life for the Quaternary worker." It is hoped that this post-flood ice-age model can provide a fresh approach to the interpretation of glacial data.

## REFERENCES


Andrews JT. 1982. On the reconstruction of Pleistocene ice sheets: a review. Quaternary Science Reviews 1:1-30.

Andrews JT, Clark P, Stravers JA. 1985. The patterns of glacial erosion across the eastern Canadian Arctic. In: Andrews JT, editor. Quaternary Environments Eastern Canadian Arctic, Baffin Bay and Western Greenland. Boston: Allen and Unwin, p 69-92.

Beget JE. 1986. Modeling the influence of till rheology on the flow and profile of the Lake Michigan lobe, southern Laurentide ice sheet, USA Journal of Glaciology 32:235-241.

Beget J. 1987. Low profile of the northwest Laurentide ice sheet. Arctic and Alpine Research 19:81-88.

Bentley CR. 1965. The land beneath the ice. In Hatherton T, editor. Antarctica. NY: Frederick A Praeger Publishers, p 259-277.

Bowen DQ. 1978. Quaternary geology: a stratigraphic framework for multidisciplinary work. NY: Pergamon Press.

Bradley RS. 1985. Quaternary paleoclimatology. Boston: Allen and Unwin.

Bray JR. 1976. Volcanic triggering of glaciation. Nature 260:414-415.

Bryan K. 1978. The ocean heat balance. Oceanus 21:19-26.

Budyko MI. 1978. The heat balance of the earth. In: Gribbin J, editor. Climatic Change. London: Cambridge University Press, p 85-113.

Bunker AF. 1976. Computations of surface energy flux and annual air-sea interaction cycles of the North Atlantic Ocean. Monthly Weather Review 104:1122-1140.

Byers HR. 1959. General meteorology. NY: McGraw-Hill.

Charlesworth JK. 1957. The Quaternary Era. 2 vols. London: Edward Arnold.

Clayton L, Teller JT, Attig JW. 1985. Surging of the southwestern part of the Laurentide ice sheet. Boreas 14:235-241.

Damon PE. 1968. The relationship between terrestrial factors and climate. In: Mitchell JM, Jr., editor. Causes of Climatic Change. Meteorological Monographs 8(30). Boston: American Meteorological Society, p 106-111.

Dansgaard W, Johnsen SJ, Clausen HB, Langway CC, Jr. 1971. Climatic record revealed by the Camp Century ice core. In: Turekian KK, editor. The Late Cenozoic Glacial Ages. New Haven, CT: Yale University Press, p 37-56.

Dansgaard W, Clausen HB, Gundestrup N, Hammer CU, Johnsen SF, Kristinsdottir PM, Reeh N. 1982. A new Greenland deep ice core. Science 218:1273-1277.

Devine JD, Sigurdsson H, Davis AN. 1984. Estimates of sulfur and chlorine yield to the atmosphere from volcanic eruptions and potential climatic effects. Journal of Geophysical Research 90(B7):6309-6325.

Dirks RA, Kuettner JP, Moore JA. 1988. Genesis of Atlantic Lows Experiment (GALE): an overview. Bulletin of the American Meteorological Society 69:148-160.

Dury GH. 1975. Discharge predictions, present and former, from channel dimensions. Journal of Hydrology 30:219-245.

Eriksson E. 1968. Air-ocean-icecap interactions in relation to climatic fluctuations and glaciation cycles. In: Mitchell JM, Jr., editor. Causes of Climatic Change. Meteorological Monographs 8(30). Boston: American Meteorological Society, p 68-92.

Fletcher JO. 1968. The influence of the arctic pack ice on climate. In: Mitchell JM, Jr., editor. Causes of Climatic Change. Meteorological Monographs 8(30). Boston: American Meteorological Society, p 93-99.

Flint RF. 1971. Glacial and Quaternary geology. NY: John Wiley and Sons.

Fristrup B. 1966. The Greenland ice cap. Seattle: University of Washington Press.

Froggatt PC, Nelson CS, Carter L, Griggs G, Black KP. 1986. An exceptionally large late Quaternary eruption from New Zealand. Nature 319:578-582.

Graham RW, Lundelius EL, Jr. 1984. Coevolutionary disequilibrium and Pleistocene extinctions. In: Martin PS, Klein RG, editors. Quaternary Extinctions: A Prehistoric Revolution. Tucson: University of Arizona Press, p 223-249.

Grayson DK. 1984. Nineteenth-century explanations of Pleistocene extinctions: a review and analysis, In: Martin PS, Klein RG, editors. Quaternary Extinctions: A Prehistoric Revolution. Tucson: University of Arizona Press, p 5-39.

Held IM. 1983. Stationary and quasi-stationary eddies in the extratropical troposphere: theory. In: Hoskins B, Pearce R, editors. Large-Scale Dynamical Processes in the Atmosphere. NY: Academic Press, p 127-168.

Hillaire-Marcel C, Grant DR, Vincent J-S. 1980. Comments and reply on 'Keewatin Ice Sheet — Re-evaluation of the traditional concept of the Laurentide Ice Sheet' and

'Glacial erosion and ice sheet divides, northeastern Laurentide Ice Sheet, on the basis of the distribution of limestone erratics'. Geology 8:466-467.

Hughes T. 1986. The Jakobshanvs effect. Geophysical Research Letters 13:46-48.

Imbrie J, Imbrie KP. 1979. Ice ages: solving the mystery. Short Hills, NJ: Enslow Publishers.

Izett GA. 1981. Volcanic ash beds: recorders of upper Cenozoic silicic pyroclastic volcanism in the western United States. Journal of Geophysical Research 86(B11):10200-10222.

John B. 1979. Ice ages: a search for reasons. In: John BS, editor. Winters of the World. NY: John Wiley and Sons, p 29-57.

Kennett JP. 1982. Marine geology. Englewood Cliffs, NJ: Prentice-Hall.

Kerr RA. 1987. Ocean hot springs similar around globe. Science 235:435.

Manabe S, Broccoli AJ. 1985. The influence of continental ice sheets on the climate of an ice age. Journal of Geophysical Research 90(D1):2167-2190.

Martin PS, Klein RG, editors. 1984. Quaternary extinctions: a prehistoric revolution. Tucson: University of Arizona Press.

Mathews WH. 1974. Surface profiles of the Laurentide ice sheet in its marginal areas. Journal of Glaciology 13:37-43.

McCauley JF, Schaber GG, Breed CS, Grolier MJ, Haynes CV, Issawi B, Elachi C, Blom R. 1982. Subsurface valleys and geoarcheology of the eastern Sahara revealed by shuttle radar. Science 218:1004-1020.

McDonald JN. 1984. The reordered North American selection regime and late Quaternary megafaunal extinctions. In: Martin PS, Klein RG, editors. Quaternary Extinctions: A Prehistoric Revolution. Tucson: Universit of Arizona Press, p 404-439.

Newson RL. 1973. Response of a general circulation model of the atmosphere to removal of the Arctic ice-cap. Nature 241:39-40.

Oard M. 1980. The flood and the ice age. Ministry (May), p 22-23.

Oard MJ. 1979. A rapid post-flood ice age. Creation Research Society Quarterly 16:29-37, 58.

Oard MJ. 1984a. Ice ages: the mystery solved? Part I: the inadequacy of a uniformitarian ice age. Creation Research Society Quarterly 21:66-76.

Oard MJ. 1984b. Ice ages: the mystery solved? Part II: the manipulation of deep-sea cores. Creation Research Society Quarterly 21:125-137.

Oard MJ. 1985. Ice ages: the mystery solved? Part III: paleomagnetic stratigraphy and data manipulation. Creation Research Society Quarterly 21:170-181.

Oard MJ. 1987. An ice age within the biblical time frame. Proceedings of the First International Conference on Creationism II:157-166. Pittsburgh: Creation Science Fellowship.

Oard MJ. In press,a. The evidence for only one ice age. Proceedings of the Second International Conference on Creationism. Pittsburgh: Creation Science Fellowship.

Oard MJ. In press,b. An ice age caused by the Genesis flood. ICR Technical Monograph. El Cajon, CA: Institute for Creation Research.

Occhietti S. 1983. Laurentide ice sheet: oceanic and climatic implications. Palaeogeography, Palaeoclimatology, Palaeoecology 44:1-22.

Pachur J-J, Kröpelin S. 1987. Wadi Howar: paleoclimatic evidence from an extinct river system in the southeastern Sahara. Science 237:298-300.

Paterson WSB. 1981. The physics of glaciers. 2nd ed. NY: Pergamon.

Ramanathan V, Cess RD, Harrison EF, Minnis P, Barkstrom BR, Ahmad E, Hartmann D. 1989. Cloud-radiative forcing and climate: results from the Earth Radiation Budget Experiment. Science 243:57-63.

Schumm SA. 1977. The fluvial system. NY: John Wiley and Sons.

Shilts WW. 1980. Flow patterns in the central North American ice sheet. Nature 286:213-218.

Smith GI, Street-Perrott FA. 1983. Pluvial lakes in the western United States. In: Wright HE, Jr., editor. Late-Quaternary Environments of the United States. Minneapolis: University of Minnesota Press, p 190-212.

Sugden DE, John BS. 1976. Glaciers and landscape. London: Edward Arnold.

Sutcliffe AJ. 1985. On the track of ice age mammals. Cambridge, MA: Harvard University Press.

Williams LD. 1979. An energy balance model of potential glacierization of Northern Canada. Arctic and Alpine Research 11:443-456.

# ANNOTATIONS FROM THE LITERATURE

## ASSUMPTIONS AFFECT CONCLUSIONS

Pagel MD, Harvey PH. 1989. Comparative methods for examining adaptation depend on evolutionary models. Folia Primatologia 53:203-220.

***Summary.*** The authors state that different methods of studying evolutionary patterns and constructing phylogenetic trees depend on different models of how evolution occurs. This concept is applied to the process of proposing ancestral states, testing for coevolution of two or more characters, and statistical comparisons of continuous characters. This paper emphasizes the importance of implicit assumptions on methodology and therefore on conclusions.

## GEOLOGY

Cox KG. 1989. The role of mantle plumes in the development of continental drainage patterns. Nature 342:873-877.

***Summary.*** This paper extends and refines previous suggestions that link flood basalt volcanism, hot mantle plumes and continental drainage patterns. The basic idea is that mantle hot spots produce hot plumes that rise toward the surface, spreading laterally near the surface. If the plume rises below a continent, uplift may result, producing a dome. Fracturing of the dome may result in rifts, flood basalt volcanism, and a characteristic pattern of continental drainage. Specific examples in India, Brazil and southern Africa are described.

## MOLECULAR CLOCK OR FOSSIL RECORD?

Easteal S. 1990. The pattern of mammalian evolution and the relative rate of molecular evolution. Genetics 124:165-173.

***Summary.*** Most of the orders of living mammals first appear around the same stratigraphic level in the fossil record. Evolutionists have generally interpreted this to indicate that the various orders arose about the same time, in a kind of explosive evolution. But all orders are not equidistant according to molecular criteria. This has been interpreted as evidence against the hypothesis that mutations occur at a generally

constant rate through evolutionary time (the molecular clock hypothesis). The author of this paper prefers the molecular clock hypothesis over evidence from the fossil record, and concludes that molecular differences indicate that mammal orders arose at different times, but the fossil record is too incomplete to indicate the order in which they arose.

## MOLECULAR PHYLOGENY OF PLANT FAMILIES?

Archie JW. 1989. Phylogenies of plant families: a demonstration of phylogenetic randomness in DNA sequence data derived from proteins. Evolution 43:1796-1800.

***Summary.*** Archie examines the results of a study of phylogenetic relationships among nine plant families based on a set of DNA sequences derived from protein sequences for three proteins. Archie concludes that the DNA sequences used do not contain phylogenetic information, and suggests procedures for identifying whether other such sequences are useful in studying phylogeny.

## PALEOBIOGEOGRAPHY AND PLATE TECTONICS

Jaeger J-J, Courtillot V, Tapponnier P. 1989. Paleontological view of the ages of the Deccan traps, the Cretaceous/Tertiary boundary, and the India-Asia collision. Geology 17:316-319.

***Summary.*** The Deccan traps are flood basalts covering a large area of India. Paleomagnetic dating indicates the volcanism that produced the Deccan traps occurred across the boundary separating the Cretaceous from the Tertiary. Fossils from below the basalts are similar to those found in beds among the lava flows, which is interpreted as evidence against rapid mass extinction. Similarities of fossils from beds among the lava flows and from Asian deposits are interpreted as evidence that the Indian plate collided with Asia much earlier than previously thought, probably close to the Cretaceous-Tertiary boundary. If so, the intracontinental shortening caused by the collision could be as much as 4000 km.

Briggs JC. 1989. The historic biogeography of India: isolation or contact? Systematic Zoology 38:322-332.

***Summary.*** Maps showing continental movements typically show India located on the north side of Antarctica, between southeast Africa

and western Australia, until about the Lower Jurassic. From this point, India is usually shown as traveling northward largely in isolation, finally colliding with the Asian continent during the lower Miocene sedimentation. The author shows that this scenario based on geophysical interpretations is not consistent with paleobiogeographical evidence. India does not show evidence of an endemic fauna or flora, but shows fossil similarities with other continents. The author supplies maps showing his interpretation of the evidence as indicating India made contact with Asia during Eocene sedimentation.

***Comment.*** The conflict between interpretations based on geophysical vs paleobiogeographical evidence remains an unsolved problem for plate tectonic theory.

## PALEONTOLOGY

Smithson TR. 1989. The earliest known reptile. Nature 342:676-678.

***Summary.*** A nearly complete, articulated skeleton of a four-legged reptile has been recovered from the black shale member of the East Kirkton Limestone in Scotland. The skeleton is about 8 inches in length. Classification has not yet been completed, but it is neither a synapsid nor a diapsid.

***Comment.*** The fossil was discovered by a private collector, and controversy has arisen over the proposed sale of the fossil for nearly $350,000.

## PRECAMBRIAN METAZOANS?

Mount JF. 1989. Re-evaluation of unconformities separating the "Ediacaran" and Cambrian systems, South Australia. Palaios 4:366-373.

***Summary.*** The top of the proposed Ediacaran stratotype in the Flinders Ranges of South Australia was previously believed located at a regional unconformity. Reinterpretation suggests it is an abrupt facies change instead, and that the Ediacaran System stratotype may actually lie well within the Lower Cambrian.

## RAPID CHANGE IN BIRDS

Diamond J, Pimm SL, Gilpin ME, LeCroy M. 1989. Rapid evolution of character displacement in myzomelid honeyeaters. American Naturalist 134:675-708.

***Summary.*** A volcanic explosion, probably about four centuries ago, destroyed all life on Long Island, an island about 50 km off the northeastern coast of New Guinea. Long Island and two nearby islands have been repopulated by a bird fauna different from that of other islands in the area which were not depopulated by the volcanic activity. The difference in species composition has apparently affected the body sizes of two species of honeyeaters.

Nine cases are known in which two species of the same genus are found living on the same newly populated island. In only one of these nine cases the two species do not occur together on any other island. In only this case individuals from Long Island differ in size as compared to individuals from other islands where the two species do not coexist. The larger species has increased in size on Long Island, while the smaller species has decreased in size. This appears to be a case of character displacement, in which size has changed in response to competition pressures, preventing one species from out-competing and eliminating the other species from the island. This change could not have taken longer than four centuries, and might have taken much less time.

## RAPID CHANGE IN INSECTS

Mallet J. 1989. The evolution of insecticide resistance: have the insects won? Trends in Evolution and Ecology 4:336-340.

***Summary.*** Resistance of insects to chemical pesticides has developed rapidly. Mechanisms of resistance include adaptations that increase behavioral avoidance, reduce cuticle permeability, increase the rate of destruction of insecticide molecules, and decrease sensitivity to the insecticide. Most of these mechanisms seem to depend on single genes, or very few genes, contrary to the expectations of neo-Darwinian theory. “Standard population genetic models have been of little use....” Mutations in regulatory genes seem more important than mutations in structural genes.

## RAPID OIL FORMATION

Didyk BM, Simoneit BRT. 1989. Hydrothermal oil of Guaymas Basin and implications for petroleum formation mechanisms. Nature 342:65-69.

***Summary.*** Oil being released in association with hydrothermal vent activity in the Gulf of California has been radiocarbon dated at less than 5000 years. The oil has similar chemical and physical properties to ordinary crude oil.

## SPECIATION AND MUTATIONS

Paigen K. 1989. Experimental approaches to the study of regulatory evolution. American Naturalist 134:440-458.

***Summary.*** Regulatory polymorphisms have been described for the genes for production of beta-globin in man and beta-glucuronidase in mice. Several steps in the regulatory process could potentially be modified by mutation, but only a limited number of such mutations is actually found. The types of mutations differ in different systems, and the regulatory differences between closely related species can be different from the polymorphisms found within a species. The types of mutations actually known in the condition called thalassemia are listed. Single substitutions accounted for 28 out of the 37 mutants known. Addition or deletion of one or a few bases were found in nine cases, the longest being a 25-base genetic deletion. The results suggest that speciation events may involve genetic mechanisms beyond those normally observed within populations.

## SPECIATION, BOTTLENECKS AND ENVIRONMENTAL STRESS

Carson HL, Wisotzkey RG. 1989. Increase in genetic variance following a population bottleneck. American Naturalist 134:668-673.

***Summary.*** A laboratory population of an endemic Hawaiian species of *Drosophila* was accidentally subjected to sustained high temperatures which killed most of the flies. The population was reconstituted from about a half dozen larvae which survived. After this population bottleneck, new combinations of chromosome 4 inversions were noted. This increase in genetic variance is the opposite of the decrease generally expected after a population bottleneck. The author does not discuss the possible effect of the high temperature, which has been reported

to increase the rates of recombination in *Drosophila* (see Parsons 1988, Biological Journal of the Linnaean Society 35:49-68).

## TAPHONOMY, FOSSILS AND CATASTROPHES

Greenstein BJ. 1989. Mass mortality of the West-Indian echinoid *Diadema antillarum* (Echinodermata: Echinoidea): a natural experiment in taphonomy. Palaios 4:487-492.

***Summary.*** During 1983 a mass die-off of sea urchins occurred throughout the Caribbean, due to disease. Mortality rates exceeded 98% in Jamaica and Curacao, and probably elsewhere. Samples taken around the island of Bonaire showed no increase in echinoderm material associated with this mass mortality event, indicating that the reef environment was not favorable to the preservation of evidence for echinoid mass mortality. Mass preservation of echinoderms in the fossil record should be interpreted as the result of unusual taphonomic processes such as rapid burial by catastrophes.

# LITERATURE REVIEWS

*Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.*

## BURGESS SHALE RE-EXAMINED

WONDERFUL LIFE. 1989. Stephen Jay Gould. NY and London: W.W. Norton and Co. 347 p., 118 illustrations. Cloth, $19.95.

*Reviewed by R. H. Brown and Harold G. Coffin, Geoscience Research Institute*

In 1909, Charles Walcott, a well-known scientist, discovered a most unusual Middle Cambrian fossil site about 3500 ft above Emerald lake in Yoho National Park, British Columbia, Canada. During several summers of work, he and his assistants extracted thousands of fossils that served as a basis for several scientific papers. In the last twenty years, renewed research on these fossils has been conducted by several paleontologists, including Harry B. Whittington of Cambridge University and two of his students, Simon Conway Morris and Derek Briggs. Their careful work has revealed a spectacular army of unusual animals so different from any that now exist that more than a dozen new phyla have been erected to classify them. Walcott's quarry has now been declared a "world heritage" site and no collecting is permitted. Indeed, no one may visit the site without an accompanying park warden.

Gould's volume is devoted to telling, in popular form, the exciting story of the rediscovery of the Burgess Shale animals, the significance of these unusual forms, and the reasons why their uniqueness and significance were not recognized by Walcott. Gould considers the Burgess Shale fossil location the most important in the world, a view that will have few challengers. Gould sees in the Burgess shale organisms remarkable confirmation of his innovative view of evolutionary progress. He challenges the conventional model of steady evolutionary development from the simplest beginning to continually more complex and more diversified organisms. He defends the view that fossils record a rapid development (sudden appearance) of a wide range

of diverse types of complex marine organisms from four Cambrian types which survived by chance.

Although Gould gives lip service to natural selection, he considers the survival of a few kinds and the extinction of many others a random process. He thinks that if the tape of life could be rewound and allowed to play again, many different scenarios would be the result. The chances of the same sequence of evolutionary development that led eventually to humans would be most unlikely. On page 14 of the Preface the author says that

> *...the 'pageant' of evolution* [is] *a staggeringly improbable series of events...utterly unpredictable and quite unrepeatable ...the chance becomes vanishingly small that anything like human intelligence would grace the replay* [of this pageant].

Chapter I is an introduction to the Burgess Shale fossils and their significance. Several surprising statements are included in this chapter. An example:

> *The familiar iconographies of evolution are all directed — sometimes crudely, sometimes subtly — toward reinforcing a comfortable view of human inevitability and superiority* (p 28).

Regarding the conventional, and still majority, view of gradual evolution, Gould says:

> *I cannot understand our continued allegiance to the manifestly false iconographies of ladder* [continued progress through time] *and cone* [predictable development to greater complexity and increasing diversity] *except as a desperate finger in the dike of cosmically justified hope and arrogance* (p 45).

Some unnecessary and unwarranted arm waving and exaggerations to support a point are also present. Note these examples:

> *Darwin has been vindicated by a rich Precambrian record, all discovered in the past thirty years* (p 57).

> *... the Burgess Shale provides our sole vista upon the inception of modern life in all its fullness* (p 56).

The richness of Precambrian fossils is certainly debatable and many other outstanding Cambrian fossil sites are known.

Those who have climbed to the Walcott quarry may disagree with Gould's downplay of the effort needed to reach it:

> *The climb [to the Walcott quarry] has some steep moments, but it qualifies as little more than a pleasant stroll, even for*

> *yours truly, overweight, out of shape, and used to life at sea level* (p 68).

Perhaps the excitement of the scenery and the mystery of a look into the past have helped erase from his mind the exertion needed for what would surely be classified as strenuous for anyone except those in excellent physical condition for climbing. The trail from Takakkaw Falls to the Walcott quarry is not four miles (as stated on p 68) but over six miles and with a 2700 ft rise in elevation. The fastest way out is a 3500 ft drop in three miles to Emerald Lake.

Chapter II presents the enigmas of conventional geochronology. As conventionally interpreted, the geologic record does not provide "a tale of predicable progress: prokaryote first, then eukaryotes, then multicellular life." Rather, it presents two disturbing questions:

> *Why did life remain at stage 1 for two-thirds of its history if complexity offers such benefits? Why did the origin of multicellular life proceed as a short pulse through three radically different faunas, rather than as a slow and continuous rise of complexity?* (p 60; see also p 56).

According to Gould, with far fewer species than now exist, the Burgess Shale quarry

> *...contains a disparity in anatomical design far exceeding the modern range throughout the world!* (p 62).

Chapter III contains 161 of the 323 pages of text in the book. It presents the scientific analysis on which the radical shift in Gould's thinking is based, and gives an intriguing story of the repeated role of bias in science. According to the dominant evolutionary thinking for over 70 years, the Burgess Shale fossils

> *...represent the primitive ancestors of nearly every class of arthropod as well as several other animal Phyla* (Y. 0. Fortier quote on p 114).

From the new perspective, "disparity reached its peak at the outset and...life's subsequent history has been a tale of decimation, not increasing variety in design" (p 120); and "the watchword for the Burgess arthropods was 'uniquely specialized,' not 'primitively simple'" (p 176).

Gould asks two major questions: How could the Burgess diversity have developed (evolved) so quickly? (p 227); and Why, of some 25 basic body plans in Burgess arthropods, did only four become enormously successful, including the dominant animals of our world

today, and all the others die out without issue? (p 238). Without answering the first question, Gould devotes major attention to the second. It is remarkable for an aggressive, deeply committed evolutionist to conclude his analysis stating:

> *...we have no evidence that the winners [among the Burgess organisms] enjoyed adaptive superiority, or that a contemporary handicapper could have designated the survivors. All that we have learned from the finest and most detailed anatomical monographs in twentieth-century paleontology portrays the Burgess losers as adequately specialized and eminently capable* (p 239).

Chapter IV is a study of the man who developed the Burgess Shale Quarry and is responsible for the interpretation of Burgess Shale fossils that has been promoted from the scientific community until the last decade. Charles Walcott was a devout Presbyterian, an ardent theistic evolutionist, and distinguished director of the Smithsonian Institution for twenty years until his death in 1927. In this chapter Gould forcefully points out how evolutionary models have represented "a philosophy of life, not the empirical record of organisms" (p 269).

Gould categorizes Walcott's interpretation of the Burgess fossils as the finest

> *...illustration of the most important message taught by the history of science: the subtle and inevitable hold that theory exerts upon data and observation. Reality does not speak to us objectively, and no scientist can be free from constraints of psyche and society. The greatest impediment to scientific innovation is usually conceptual lock, not a factual lack* (p 276).

It seems that this statement applies just as much to Gould's concept of evolution as it does to Walcott's. The sudden diversity of Burgess Shale organisms could easily be interpreted as suggesting their separate creation, but this possibility is not even considered by Gould.

The extended discussion of Walcott as a person, his view of evolution, his attempt to 'shoehorn' all the Burgess Shale animals into the modern classification, and his subsequent failure to complete the study of the fossils he collected make an interesting contribution to the history of American paleontology. However, Gould may be too severe concerning Walcott's rigidity in classification. Hindsight is always better than foresight. Considering the orthodoxy of evolutionary thinking that

dominated in Walcott's time, he did what one might expect. Furthermore, the crowding out of research by administrative responsibilities is an easily understandable problem that many can sympathize with. Among many responsibilities he was director of the U. S. Geological Survey, and head of the Smithsonian Institution. In the perspective of time, we may surmise that his greatest contribution to science was in the work he did aside from his study of the Burgess Shale fossils. His impact on science as an administrator in some of the major science institutions of the nation must not be underrated.

The final chapter, V, presents speculations which attempt to explain an evolutionary transition from the world of the Burgess Shale fossil organisms to the world of modern organisms. For many readers this chapter will be noted for multiplication of words, and will suffer in contrast with the stimulating prose of the previous four chapters. But it contains many choice and stimulating statements. For example, on page 307 the author says:

> *I also strongly suspect that in a great majority of cases, the traits that enhance survival during an extinction do so in ways that are incidental and unrelated to the causes of their evolution in the first place.*

Accordingly,

> *Unpredictability must rule if geological longevity depends upon lucky side consequences of features evolved for other reasons* (p 308).

Although written by an outstanding and committed evolutionist, this book fosters the conviction that one must believe in "evolution" without any reasonable model for that belief; that despite this crucial lack such belief must be held if one is unwilling to accept any other explanation for our origin. Readers of this review should recognize that a committed evolutionist will make somewhat different assessments from those which have been developed from our viewpoints.

The book combines interesting narrative, careful research and even suspense (the labored philosophy of Chapter V excepted). Furthermore, it presents a picture largely consistent with the origin of life by sudden creation (although Gould did not have this intention when he wrote it). We highly recommend its reading.

# GENERAL SCIENCE NOTES

## A CATASTROPHE WITH AN IMPACT

*By L. James Gibson, Geoscience Research Institute*

### INTRODUCTION

As one moves up or down through the stratigraphic column, the types of fossil organisms often change abruptly. The boundary dividing Permian and Triassic sediments is an example. An estimated 96% of all fossil species found below this boundary are not found above it (Raup 1979, Sepkoski 1989). The sudden change from the presence of a particular type of fossil to its absence in overlying strata is called an extinction. Extinction of many species at approximately the same stratigraphic boundary is termed a mass extinction. The greatest mass extinction occurred at the boundary between the Permian and the Triassic, and is used to divide Paleozoic from Mesozoic sediments.

Another mass extinction occurred at the boundary between the Cretaceous and the Tertiary, dividing Mesozoic and Cenozoic sediments. Because this latter extinction includes the dinosaurs, it is of considerable interest both to scientists and the public. The cause for the extinction of the dinosaurs remains a puzzle. Dinosaur fossils are commonly found in Mesozoic sediments, but not in the overlying Tertiary sediments. A few reports of Tertiary dinosaurs have been claimed (e.g., Sloan et al. 1986, Rigby et al. 1987, Van Valen 1988), but these are rare and controversial. Although the dinosaurs are the most famous example, abrupt faunal change is a common feature of the stratigraphic column.

In 1980, a team of researchers reported (Alvarez et al. 1980) the finding of an unusually high concentration of iridium in a clay band at the boundary between the Cretaceous and the Tertiary. This iridium anomaly, as it was called, has been found in several localities in Europe, North America and New Zealand. Iridium is rare in the crust of the earth, but is more common in meteorites and in the mantle of the earth. The Alvarez team suggested that the source for the iridium was a very large meteorite that had collided with the earth. Such an impact might also have upset the ecological balance of the earth, causing many species to become extinct. This might explain the disappearance of the dinosaurs, along with many other groups that are not found in sediments above the Cretaceous.

The impact hypothesis has generated a great amount of interest among scientists. Although the idea of an extraterrestrial impact had been suggested earlier (e.g., McLaren 1970), the iridium anomaly was the first evidence that made such an explanation seem worth investigating. Not only geologists and paleontologists have become interested, but also astronomers, oceanographers, and biologists from many disciplines. The number of scientific papers on this topic has already probably exceeded that for any other geological hypothesis of this century except for that of plate tectonics (Glen 1989).

## QUESTIONS CONCERNING THE END-CRETACEOUS EXTINCTION

Before considering the impact hypothesis in detail, the reality of a mass extinction should be established. About 60-76% of all Cretaceous marine species (Crutzen 1987), including 90% of coccolithophorid genera and planktonic foraminifera (McLean 1985) are not found in sediments above the Cretaceous. Other groups found in the Cretaceous but not in overlying strata include the dinosaurs, ichthyosaurs, pterosaurs, ammonites, and several groups of invertebrates. Thus there is considerable extinction across the Cretaceous-Tertiary (KT) boundary.

Some have questioned whether so-called mass extinctions are truly different from the extinction rates characteristic of other portions of the geologic column (Benson 1985, McKinney 1987). It is claimed that apparent mass extinctions may be the result of low origination rates combined with extinction rates only slightly higher than background rates. Despite this challenge, dramatic faunal changes do occur across some stratigraphic boundaries, and scientific investigation seems justified.

Any hypothesis proposed to explain the KT boundary mass extinction must also explain the selectivity of the extinctions. Marine families suffered the highest rates of extinction, with less effect on terrestrial groups (Jablonski 1986, McKinney 1987, Officer et al. 1987). Freshwater communities were almost unaffected (Crutzen 1987, Hutchinson & Archibald 1986), as were insects (Whalley 1987). Among plants, deciduous trees survived better than evergreen taxa (Wolfe & Upchurch 1987), and a sudden change from angiosperm pollen to fern pollen has been recorded at the boundary in Japan (Saito, Yamanoi & Kaiho 1986) and in Canada (Nichols et al. 1986).

The extinctions may also have been influenced by geography. A major floral turnover is reported from Siberia and western North America, but not from the southern hemisphere (Collinson 1986). Similarly, mar-

supials were reportedly more affected in North American than in South America (Case & Woodburne 1986, but see Van Valen 1988). Having considered some of the features of the extinctions of the KT boundary, we can now examine the impact hypothesis itself.

## THE IMPACT HYPOTHESIS

Geologic features of the KT boundary present interesting evidence relating to possible causes of the mass extinction. The widespread existence of the boundary clay has been interpreted as evidence for a worldwide event at the boundary. In addition to the high iridium levels, shocked quartz grains are also found at the boundary (Bohor et al. 1984), and high levels of carbon, mainly soot (Wolbach et al. 1988). Together, these features have led to the development of the impact hypothesis as a cause of mass extinctions. The production of shocked quartz grains requires an event of considerable force, such as a nuclear explosion or meteorite impact. The soot is explained as possibly the result of a global fire triggered by heat from an impact by a meteorite or asteroid. But how large would such an object have been, and what would be the results of such an impact? And is there any other evidence for an impact, such as an appropriate crater?

The size of the impact object can be extrapolated from the amount of iridium in the boundary clay compared to that in extraterrestrial material. Based on this extrapolation, the extraterrestrial object is hypothesized to have been about 10 km in diameter. Such an object would have a mass of about $5\times10^{15}$ kg and a velocity of perhaps $2\times10^{4}$ m/sec. The energy dissipated at the impact would have been about $10^{23}$-$10^{24}$ Joules (Crutzen 1987). This is roughly equivalent to one million times the amount of energy released by the 1964 Alaska earthquake.

The impact of a 10-km diameter asteroid would cause a catastrophe beyond our ability to envision. The results of such an impact (Clube and Napier 1982, Albritton 1989) might include a blast wave that would kill off any life over half the world, with an air temperature of 500° and windspeed of about 2500 km/hr. The heat of the impact might ignite widespread forest fires, accounting for the layer of soot found in New Zealand, Europe and North America (Melosh et al. 1990). Nitric oxides produced in the fireball would destroy the earth's ozone level, exposing survivors to life-threatening ultraviolet light. Global earthquakes with ground waves 10 m high would result. If the comet hit the ocean, it could generate waves 500-1000 m high at a distance of 2000 km from

the impact target. The earth's core would be disrupted, possibly producing magnetic reversals. Plate movement would be accelerated, opening cracks 10-100 km wide in the earth's crust, and causing rapid mountain-building and worldwide volcanism (Clube & Napier 1982). It is difficult to understand how any significant number of species could survive such an event.

The resulting dust cloud would obscure the sun for several months, causing prolonged darkness, cooling, and acid rain (Crutzen 1987, Diamond 1983). Many species could not cope with such alterations of the environment and would become extinct. Species resistant to the environmental disturbance would be more likely to survive, explaining the selective nature of the extinctions. In view of its spectacular nature, it is no wonder that the impact hypothesis has generated so much interest.

## HAVE THERE BEEN MULTIPLE IMPACTS?

Analysis of extinction rates has been interpreted to suggest that mass extinctions may have occurred repeatedly in the stratigraphic column, being fairly typical of geological period boundaries. The greatest mass extinction occurred at the Permian-Triassic boundary. Not only did most of the Paleozoic species become extinct across that boundary, but the fossils seem to represent different ecological conditions. Paleozoic marine fossils are said to be predominantly from sessile epifaunal groups, while more mobile types predominate in the Mesozoic sediments (Erwin 1989).

Further analysis of mass extinctions has led to the proposal that such extinctions are periodic (Raup & Sepkoski 1984, 1988; Fox 1987), occurring on average about every 25-26 Ma (million years). A mechanism for periodicity has been proposed (Clube & Napier 1982, Napier & Clube 1979), relating periodic comet showers to the capture of material by the solar system as it crosses roughly equally spaced regions of the Milky Way galaxy where matter is denser.

Challenges have been presented to both the periodicity of the mass extinctions and their causation by extraterrestrial impacts. The periodicity of mass extinctions has been variously described as statistically unjustified (Benson 1985, McKinney 1987) or a statistical artefact of arbitrary decisions concerning the dating of stratigraphical boundaries, the average time for a "stage" and the definition of mass extinction (Hoffman 1985, Benton 1985). Another area of attack is the accuracy of the extinction data. Only about 25% of the extinction data for families of marine fish

and echinoderms is considered to be valid (Patterson & Smith 1987, 1989). At the genus level, less than 12% of the extinctions were judged valid. Patterson and Smith (1989) suggest that purported periodic peaks in diversity and apparent extinction may be related to the depositional history (taphonomy) of the fossils rather than to faunal changes. Another argument has been that most mass extinctions are not associated with evidence for extraterrestrial impacts (Erwin 1989, Kyte & Wasson 1986, Quinn & Signor 1989). Impacts have been plausibly linked to only a few mass extinctions other than the end-Cretaceous extinction (Jansa & Pe-Piper 1987; Kyte, Zhou & Wasson 1988; Olsen, Shubin & Anders 1987).

## CRITICISMS OF THE IMPACT HYPOTHESIS

The impact hypothesis for the end-Cretaceous mass extinction has also been attacked. One of the chief points of attack has been the purported stepwise character of the extinctions. If mass extinctions were caused by an extraterrestrial impact they should occur simultaneously in the fossil record. However, the extinctions allegedly occurred in steps for such groups as ammonites and rudist bivalves (Donovan 1987) and dinosaurs (Rigby et al. 1987, Sloan et al. 1986), although the Paleocene dinosaurs may be reworked from Cretaceous sediments (Eaton, Kirkland & Doi 1989, Fastovsky 1987). In any case, dinosaurs might have been resistant to the cold weather supposedly produced by the impact, since they have been found in Australia during the early Cretaceous. According to plate tectonic reconstruction, Australia is believed to have been within the Antarctic Circle (80°) in the early Cretaceous (Rich et al. 1988). It may be possible to reconcile the stepwise nature of the mass extinction with the impact hypothesis by proposing a "shower" of comets rather than a single very large impact (Hut et al. 1987).

Additional challenges to the impact hypothesis for the end-Cretaceous extinction include claims that evidence of purported extraterrestrial material is lacking at some KT boundary sections (Rampino & Reynolds 1983, Officer et al. 1987), while it is sometimes found in places other than the boundary (Officer & Drake 1983, Officer et al. 1987). McLean (1985) sees no evidence for global darkening, cooling or catastrophe. Van Valen (1984) points to the absence of turbidites at the boundary as ruling out an oceanic impact, and the absence of a suitable crater as ruling out a terrestrial impact large enough to cause the end-Cretaceous extinctions.

## VOLCANISM: AN ALTERNATIVE HYPOTHESIS

An alternative hypothesis of the cause of mass extinctions is that they were caused by terrestrial processes such as volcanism and tectonism. High iridium concentrations are not found in a periodic manner in the geologic column (Kyte & Wasson 1986), as should be the case if extinctions are caused by periodic extraterrestrial impacts. Iridium has been found in volcanic dust from Krakotoa (Officer & Drake 1983) and the Hawaiian Kilauea volcano (Zoller, Parrington & Kotra 1983), suggesting volcanism as a possible source for the iridium. Other elements more typical of the earth's mantle than of extraterrestrial material have reportedly also been found in the boundary clay at some locations (Gilmore et al. 1984; Zoller, Parrington & Kotra 1983). The boundary clay in some sections is not lithologically unusual (Rampino & Reynolds 1983). It is claimed that shocked quartz grains may be accounted for by volcanism better than by impact, because the particles would have been transported out of the atmosphere by an impact and should have lost their shock features on reentry (Officer et al. 1987). Marine KT boundaries do not appear to be synchronous (Officer & Drake 1983), and have not been successfully correlated with terrestrial KT boundaries (McLean 1985).

Correlated periodicities of mass extinctions, and continental flood basalt volcanism have been proposed (Rampino 1987, Rampino & Stothers 1988). Episodes of large-scale volcanism are suggested to have been caused by periodic showers of comets, with both factors contributing to mass extinctions. Mass extinctions and flood basalt volcanism have both been linked to increased frequencies of geomagnetic reversals (Loper, McCartney & Buzyna 1988), with the suggestion that mantle activity may be causally related to all three phenomena.

The Deccan Traps in India are a very large volcanic outpouring, covering at least 500,000 $km^2$ (Rampino & Stothers 1988), and occurring across the KT boundary (Jaeger et al. 1989). Unusual tectonism, seafloor spreading and major sea level changes also occurred at or about the KT boundary, and there seems to be no need to invoke an extraterrestrial impact (Moses 1989). The Deccan Traps would have released about $5\times10^{17}$ moles of carbon dioxide, which is about 9 times the total of the modern atmosphere (McLean 1985). This is suggested as an explanation for the apparent lack of life in the ocean at the time of the KT boundary.

Many of these points, together with a few others, are reviewed by Van Valen (1984), who tends to favor the volcanic hypothesis. In evaluating the discussion, he states: "I conclude that selective use of the available evidence can prove either gradualism or catastrophism, and that neither kind of evidence seriously affects the other." It may be that scientific conclusions are influenced by the philosophical views of the scientist nearly as much as by the data.

## SIGNIFICANCE TO CREATIONISM

The discussion of mass extinctions and their possible causes should be of great interest to creationists. Investigations of the nature of species changes through the stratigraphic column could lead to better understanding of the causes of stratigraphic sorting of fossils. The stepwise character of extinctions might be the result of different source areas and differential sorting by the waters of the flood. One observation that may be useful is that marine fossils trend from predominantly sessile types in Paleozoic sediments to more mobile types in Mesozoic sediments (Erwin 1989). Other ideas to investigate include stratigraphic trends in paleobiogeographic relationships, lithologies, and paleocurrents.

Discussions of the possible effects of volcanism and meteoric impacts are also of interest to creationists. Large volcanic flows (Rampino & Stothers 1988) and numerous craters apparently caused by extraterrestrial impacts (Napier & Clube 1979, Grieve 1990) are found within the layers of the stratigraphic column, indicating their occurrence during the accumulation of the sediments. The occurrence of all or most of these events within the relatively short period of the biblical flood implies a catastrophe of unprecedented magnitude. Despite this, few creationists have seriously studied the possibility of events as catastrophic as those currently being discussed in the evolutionary community. The possibility that a large extraterrestrial impact was an important energy source for the break-up of the earth's crust and release of the "fountains of the deep" that occurred during the flood should be considered.

The present discussion should not be interpreted as demonstrating the validity of the biblical flood story. However, although geologists generally take great care to emphasize that they do not accept the story of the biblical flood, the current discussion of the geological and paleontological evidence seem to enhance the respectability of such a worldwide catastrophe. More importantly, the on-going debate provides

new data and new ideas that creationists may be able to utilize in developing a better understanding of processes that may have occurred during the flood.

## SUMMARY

Recognition of mass extinctions, linked stratigraphically with unusual geologic activity and geochemical features, has resulted in two competing hypotheses to explain mass extinctions. The impact hypothesis states that the earth has collided with one or more asteroids, each collision raising a dust cloud which induced such environmental changes that an abrupt global mass extinction occurred. The volcanic hypothesis states that the mass extinctions have been caused by episodes of flood basalt volcanism, producing global environmental changes. Under these conditions mass extinctions would have occurred over longer periods of time, although still relatively abrupt on a geological timescale. A strong debate among advocates of the opposing viewpoints has ensued, with neither side able to convincingly disprove the other hypothesis. This is an interesting example of scientific debate which helps to demonstrate the nature of scientific inquiry. The focus on catastrophic activity may be useful in developing models of the worldwide flood described in the scriptures.

## LITERATURE CITED

Albritton CC. 1989. Catastrophic episodes in earth history. London and NY: Chapman and Hall.

Alvarez LW, Alvarez W, Asaro F, Michel HV. 1980. Extraterrestrial cause for the Cretaceous-Tertiary extinction. Science 208:1095-1108.

Benton MJ. 1985. Mass extinction among non-marine tetrapods. Nature 316:811-814.

Bohor BF, Foord EE, Modreski PJ, Triplehorn DM. 1984. Mineralogic evidence for an impact event at the Cretaceous-Tertiary boundary. Science 224:867-869.

Case JA, Woodburne MO. 1986. South American marsupials: a successful crossing of the Cretaceous-Tertiary boundary. Palaios 1:413-416.

Clube V, Napier B. 1982. Close encounters with a million comets. New Scientist 95:148-151.

Collinson ME. 1986. Catastrophic vegetation changes. Nature 324:112.

Crutzen PJ. 1987. Acid rain at the KT boundary. Nature 330:108-109.

Diamond JM. 1983. Extinctions, catastrophic and gradual. Nature 304:396-397.

Donovan SK. 1987. How sudden is sudden? Nature 328:109.

Eaton JG, Kirkland JI, Doi K. 1989. Evidence of reworked Cretaceous fossils and their bearing on the existence of Tertiary dinosaurs. Palaios 4:281-286.

Erwin DH. 1989. The end-Permian mass extinction: what really happened and did it matter? Trends in Ecology and Evolution 4:225-229.

Fastovsky DE. 1987. Paleoenvironments of vertebrate-bearing strata during the Cretaceous-Paleogene transition, eastern Montana and western North Dakota. Palaios 2:282-295.

Fox WT. 1987. Harmonic analysis of periodic extinctions. Paleobiology 13:257-271.

Gilmore JS, Knight JD, Orth CJ, Pillmore CL, Tschudy RH. 1984. Trace element patterns at a non-marine Cretaceous-Tertiary boundary. Nature 307:224-228.

Glen W. 1989. The growing mass extinction controversies: impacts? volcanisms? periodicity? Palaios 4:497-500.

Grieve RAF. 1990. Impact cratering on the earth. Scientific American 262(4):66-73.

Hoffman A. 1985. Patterns of family extinction depend on definition and geological timescale. Nature 315:659-662.

Hut P, Alvarez W, Elder WP, Hansen R, Kauffman EG, Keller G, Shoemaker EM, Weissman PR. 1987. Comet showers as a cause of mass extinctions. Nature 329:118-126.

Hutchinson JH, Archibald JD. 1986. Diversity of turtles across the Cretaceous/Tertiary boundary in northeastern Montana. Palaeogeography, Palaeoclimatology, Palaeoecology 55:1-22.

Jablonski D. 1986. Background and mass extinctions the alternation of macroevolutionary regimes. Science 231:129-133.

Jaeger J-J, Courtillot V, Tapponnier P. 1989. Paleontological view of the ages of the Deccan Traps, the Cretaceous/Tertiary boundary, and the India-Asia collision. Geology 17:316-319.

Jansa LF, Pe-Piper C. 1987. Identification of an underwater extraterrestrial impact crater. Nature 327:612-614.

Kyte FT, Wasson JT. 1986. Accretion rate of extraterrestrial matter: iridium deposited 33 to 67 million years ago. Science 232:1225-1229.

Kyte FT, Zhou L, Wasson JT. 1988. New evidence on the size and possible effects of a Late Pliocene oceanic asteroid impact. Science 241:63-65.

Loper DE, McCartney K, Buzyna G. 1988. A model of correlated episodicity in magnetic-field reversals, climate, and mass extinctions. Journal of Geology 96:1-15.

McKinney ML. 1987. Taxonomic selectivity and continuous variation in mass and background extinctions of marine taxa. Nature 325:143-145.

McLean DM. 1985. Mantle degassing unification of the trans- K-T geobiological record. Evolutionary Biology 19:287-313.

Melosh HJ, Schneider NM, Zahnle KJ, Latham D. 1990. Ignition of global wildfires at the Cretaceous/Tertiary boundary. Nature 343:251-254.

Moses CO. 1989. A geochemical perspective on the causes and periodicity of mass extinctions. Ecology 70:812-823.

Napier WM, Clube SVM. 1979. A theory of terrestrial catastrophism. Nature 282:455-459.

Nichols DJ, Jarzen DM, Orth CJ, Oliver PQ. 1986. Palynological and iridium anomalies at Cretaceous-Tertiary boundary, south-central Saskatchewan. Science 231:714-717.

Officer CB, Drake CL. 1983. The Cretaceous-Tertiary transition. Science 219:1383-1390.

Officer CB, Hallam A, Drake CL, Devine JD. 1987. Late Cretaceous and paroxysmal Cretaceous/Tertiary extinctions. Nature 326:143-149.

Olsen PE, Shubin NH, Anders MH. 1987. New Early Jurassic tetrapod assemblages constrain Triassic-Jurassic tetrapod extinction event. Science 237:1025-1029.

Patterson C, Smith AB. 1987. Is the periodicity of extinctions a taxonomic artefact? Nature 330:248-252.

Patterson C, Smith AB. 1989. Periodicity in extinction: the role of systematics. Ecology 70:802-811.

Quinn JF, Signor PW. 1989. Death stars, ecology, and mass extinction. Ecology 70:824-834.

Rampino MR, Reynolds RC. 1983. Clay mineralogy of the Cretaceous-Tertiary boundary clay. Science 219:495-498.

Rampino MR, Stothers RB. 1988. Flood basalt volcanism during the past 250 million years. Science 241:663-668.

Raup DM. Size of the Permo-Triassic bottleneck and its evolutionary implications. Science 205:217-218.

Raup DM, Sepkoski JJ. 1984. Periodicity of extinctions in the geologic past. Proceedings of the National Academy of Sciences (USA) 81:801-805.

Raup DM, Sepkoski JJ. 1988. Periodic extinction of families and genera. Science 231:833-836.

Rich PV, Rich TH, Wagstaff BE, Mason JM, Douthitt CB, Gregory RT, Felton EA. 1988. Evidence for low temperatures and biologic diversity in Cretaceous high latitudes of Australia. Science 242:1403-1406.

Rigby JK, Jr, Newman KR, Smith J, van der Kaars S, Sloan RE, Rigby JK. 1987. Dinosaurs from the Paleocene part of the Hell Creek Formation, McCone County, Montana. Palaios 2:296-302.

Saito T, Yamanoi T, Kaiho K. 1986. End-Cretaceous devastation of terrestrial flora in the boreal Far East. Nature 323:253-255.

Sepkoski JJ. 1989. Periodicity in extinction and the problem of catastrophism in the history of life. Journal of the Geological Society of London 146:7-19.

Sloan RE, Rigby JK, Van Valen LM, Gabriel D. 1986. Gradual dinosaur extinction and simultaneous ungulate radiation in the Hell Creek Formation. Science 232:629-633.

Van Valen LM. 1984. Catastrophes, expectations, and the evidence. Paleobiology 10:121-137.

Van Valen LM. 1988. Paleocene dinosaurs or Cretaceous ungulates in South America? Evolutionary Monographs No. 10.

Whalley P. 1987. Insects and Cretaceous mass extinction (letter). Science 327:562.

Wolbach WS, Gilmour I, Anders E, Orth CJ, Brooks RR. 1988. Global fire at the Cretaceous-Tertiary boundary. Nature 334:665-669.

Wolfe JA, Upchurch GR. 1987. Leaf assemblages across the Cretaceous-Tertiary boundary in the Raton Basin, New Mexico and Colorado. Proceedings of the National Academy of Sciences (USA) 84:5096-5100.

Zoller WH, Parrington JR, Phelan Kotra JM. 1983. Iridium enrichment in airborne particles from Kilauea volcano: January 1983. Science 222:1181-1121.

# EDITORIAL

## FLOOD STORIES — CAN THEY BE IGNORED?

One of the objections voiced against geologists who believe a flood to be a major geologic event of the past (flood geologists) is that they often begin with the proposition that the biblical account of the flood is true and then attempt to fit the scientific data into that given model. It is sometimes further implied that religious commitment and bias is the basis for selection of data to fit the concept; hence, one is not dealing with a fair and open system of inquiry. While there is bias and commitment in all broad areas of inquiry, in this case one needs not turn to the Bible or religion to find support for flood geology. The idea of a dreadful flood, sometimes called the deluge, is remarkably entrenched in non-biblical sources. Such sources serve as an independent basis for evaluating such an event.

The most important extrabiblical flood account is found in the Gilgamesh Epic, the outstanding literary work from ancient Babylon. It was discovered during archaeological evacuation at Nineveh in the famous library of the Assyrian king Ashurbanipal. which dates from about the 7th century B.C. The epic is written on 12 tablets in cuneiform (wedge shaped) script of the semitic Akkadian language. The hero of the story, Gilgamesh, is in search of eternal life and strongly protests against death. He seeks out Utnapishtim who has been granted eternal life because he saved animal and human life at the time of the great flood.[1] The flood account, which is reported on tablet No. 11, is remarkably similar to the biblical account given in Genesis. There is general agreement among scholars that the two accounts are related because of close similarities. For instance, in both accounts: a) the flood is brought on because of evil on earth; b) the flood is divinely planned; c) the hero is instructed to build an ark for the preservation of mankind and animals; d) a select group of mankind, animals, and provisions are taken into the ark; e) the event is universal;[2] f) after the flood subsides the hero releases a raven and a dove (the Babylonian account also has a swallow; however, in a different sequence) to test the dryness of the land; g) at the flood's end a sacrifice offered to deity is well accepted.

The ancient Greeks also had the concept of a deluge.[3] Their flood hero, Deucalion, was advised by his father to construct an ark because the god Zeus wished to destroy mankind. Deucalion and his wife entered the ark after stocking it with provisions. Zeus caused such a great rain that in nine days it washed down the greater part of Greece. Most men perished, except a few who fled to high mountains. Deucalion also survived in his ark. There were other Greek stories of a deluge. Some scholars distinguished three such events, although the one associated with Deucalion is the most famous.[4]

The Aztecs of Central America also had the concept of one or several deluges. These flood concepts antedate the 16th-century advent of missionaries, who brought the flood story from the Bible. The Aztec legend of beginnings[5] includes an original earth which was destroyed by a great flood caused by the rain god Tlaloc. One account indicates that after the creation of the world there was a period of 1716 years before its destruction by flood and lightning.[6] Severe earthquakes followed.Tlazolteolt is "the woman who sinned before the deluge", while the flood heroes Nata and Nena escaped the ravages by building themselves a ship. Others escaped by taking refuge in caverns or mountaintops. The threat of subsequent deluges was taken very seriously, and the Aztecs are reported to have sacrificed large numbers of children to the rain god Tlaloc as appeasement.

In ancient history a major flood was not just considered as plausible but was factually incorporated into the thought systems. For instance, man's early historical account was often divided into pre-flood and post-flood groupings. Aristotle wrote about the ravages of the deluge in the time of Deucalion. Plato also mentions the flood which took place in Deucalion's time.[7] Later in the second century A.D., in the town of Apamea[8] in Asia Minor, coins were issued which had images of the ark, Noah and his wife, a dove, etc.[9] While it seems likely that there had been Jewish biblical influence by this time, issuing a coin to commemorate the deluge indicates how important that event was considered.

The accounts given above represent a minute sample of the available flood stories. Instead of elaborating further on this theme, consideration will be given to the objections that have been raised about the authenticity of these accounts.

One of the most prevalent criticisms is that these ubiquitous flood accounts are derived locally, possibly from local floods,[10] and are not from a worldwide event as described in the Bible. The point is difficult to substantiate. It is probable that some of these accounts have a local origin. Many of them vary in details, as the examples given above have shown. However, variations would be expected if the story originated in Asia Minor, as seems to be the case,[11] and was passed on orally from generation to generation. The oldest accounts and the ones most similar to the biblical one are found in Asia Minor. On the other hand, certain themes such as a favored family saved, a universal deluge, and birds sent out to test for dry land, are well distributed over the world.[12] These worldwide characteristic themes challenge the local-flood concept.

In 1929 the British archaeologist Sir Leonard Woolley electrified the archaeological world when he announced that he had discovered a deposit of the biblical deluge in his diggings at Ur of the Chaldees in Mesopotamia. About 40 feet down, Woolley found between layers of human occupation a 10-foot layer of silt and sand that contained no archaeological artifacts. (Other workers found a similar layer at Kish and at several other ancient Mesopotamian

cities.) Woolley interpreted this layer to be caused by the flood of Noah, which he considered to be local rather than worldwide. His concept has not survived careful scrutiny. The deposit that Woolley found was too young to fit even with biblical dating for the flood. Besides, it could not even be found all over the town of Ur. The other deposits at Kish and elsewhere turned out to be younger than the one at Ur.[13] These are very localized deposits which do not fit the cataclysm usually depicted in flood stories.

Another objection to the validity of flood stories is that they may have resulted form the influence of missionaries traveling over the world spreading their biblical teachings. While this is recognized to be the case in a few instances, it is an objection that is not taken very seriously, since most of these deluge accounts antedate the advent of Christian missionaries.

Some suggest that the biblical flood account is based on Babylonian and earlier myths, instead of an actual event.[14] There is no question that the Babylonian and biblical accounts are related, since so many details are similar in both. Conversely, it has been suggested that the Babylonian accounts were based on the biblical one. One could assume this for later versions, such as the Gilgamesh Epic probably dating from the 7th century B.C. This proposition has not stood the test of more recent inquiry since Sumerian texts that precede the Babylonian texts and the earliest assumed time for the writing of the biblical text have been found. The biblical Genesis account was probably written about the 15th century B.C., while some Sumerian flood tablets most likely originated many centuries earlier.[15] Sumerian writing is the oldest literature known, and it is of interest that here also we find a flood account.

In support of the view that the biblical account is based on Babylonian myths, attempts have been made to show Babylonian influences on the biblical text. Such efforts are rather poor arguments, since similarities of terminology purporting relationship between the two are not unique.[16] One must also recognize that in comparison to the Sumerian and Babylonian stories, there are unique aspects to the biblical account. The Bible gives the most detailed account available and is fiercely monotheistic (one God), while the other accounts are strongly polytheistic (many gods).

More significant to the question of the origin of flood stories is the proposal by Alexander Heidel of the Oriental Institute of the University of Chicago[17] that these flood legends all have a common origin. While Heidel feels this point is not proven, there is one factor that belies all other explanations; namely: how can one explain the worldwide dominance of stories about this kind of catastrophe if it did not have a common basis? A common origin[18] lends confirmation to the biblical model, according to which the flood story would be spread from Asia Minor by the few survivors of the flood as they repopulated the earth. The Genesis account would also be based on the event itself.

Some 270 flood stores have been recorded around the world.[19] The literature discussing them is abundant.[20] Their geographical distribution is not uniform, but is generally worldwide. They are most common in Asia, islands south of Asia, and the New World, being found from Tierra del Fuego to north of the Arctic Circle. They are more rare in Africa and Europe. Specific localities where they are especially noted include Egypt, Greece, Persia, Syria, Italy, Wales, Scandinavia, Russia, India, China, Mexico, Indonesia, New Guinea, Melanesia, Polynesia, Micronesia and Australia.

Many scholars testify to the fact that accounts of a deluge are essentially coexistent with nearly all of the human family.[21] What is more significant is their unusual abundance. Even those who do not believe in a worldwide deluge acknowledge this. Albright speaks of the "extraordinary diffusion of deluge stories over the world."[22] Gaster states: "Legends of a primeval deluge...are a feature of almost all primitive mythologies";[23] Woods states that these accounts "are remarkably frequent in the folklore of the ancient literature of peoples scattered over the greater part of the world";[24] and Huggett, in his book on flood concepts, reflects the same when he comments: "It is exceedingly difficult to say just why so many ancient cultures should believe in cataclysms."[25]

Stith Thompson has compiled and organized motifs in folk literature into a monumental five-volume treatise.[26] This listing includes some 33,000 specific motifs, all of which have referenced accounts. The literature dealing with past world calamities shows a definite preponderance of comment concerning the deluge, both in terms of motifs and references. The number of references for specific causes of past world calamities in Thompson's Index is as follows: deluge 122, fire 19, continuous winter 6, large stones 2, misc. 4. It is noteworthy that common causes of calamities such as earthquakes, volcanic eruptions, pestilence, and drought are not listed. This also testifies to the remarkable commonness of flood traditions which have been present from the time of man's earliest writing to the present. One could hardly expect that accounts of major catastrophes from all over the world would be so selective of one theme of catastrophe if it had not been based on an actual worldwide event. This dominance strains the proposal that these accounts arose locally.

Whether one is a flood geologist, a no-flood geologist, or otherwise, the flood cannot be readily discarded as an incidental historical event. Furthermore, questions concerning this event are the bases of much of the controversy between creation and evolution. Creationists use this event to explain much of the data for which mainstream geologists propose geologic time and evolutionary trends in fossils. It turns out that this event has rather impressive non-biblical authentication. Any system of explanation for origins can ill afford to deny the deluge.

Ariel A. Roth

## ENDNOTES


1. For an English rendition, see: Heidel A. 1949. The Gilgamesh Epic and Old Testament parallels. 2nd ed. Chicago: The University of Chicago Press, p 80-93.
2. Ibid, p 249.
3. Frazer JB. 1918. Folk-lore in the Old Testament. Vol 1 (of 3). London: Macmillan, p 66-67.
4. Ibid, p 70.
5. Sykes E. 1965. Everyman's dictionary of non-classical mythology. Rev. ed. London: J. M. Dent & Sons, p 24.
6. Vaillant GC. 1962. Aztecs of Mexico: origin, rise and fall of the Aztec nation. Rev. ed. Garden City, NY: Doubleday, p 56.
7. Frazer p 67 (Note 3).
8. Teeple HM. 1978. The Noah's are nonsense. Evanston, IL: Religion and Ethics Institute, p 39.
9. Nelson BC. 1968. The deluge story in stone. 2nd ed. Minneapolis, MN: Bethany Fellowship, p 176.
10. Woods FH. 1959. Deluge. In: Hastings J, editor. Encyclopaedia of Religion and Ethics, Vol. 4. NY: charles Scribner's Sons, p 545-557.
11. Teeple, p 40 (Note 8).
12. See Fig. 38, p 169 in Nelson (Note 9).
13. (a) Albright WF. 1936, 1955. Recent discoveries in Bible lands. Supplement. In: Young's Analytical Concordance to the Bible. NY: Funk & Wagnalls, p 30; (b) Filby FA. 1970. The flood reconsidered. Grand Rapids, MI: Zondervan Publishing House, p 28-30.
14. For a comparison of these with the biblical text, see: Shea WH. 1984. A comparison of narrative elements in ancient Mesopotamian creation-flood stories with Genesis 1-9. Origins 11:9-29.
15. Heidel, p 236 (Note 1).
16. Ibid., p 264-267.
17. Ibid., p 267.
18. Teeple, p 10-40 (Note 8).
19. Vos HF. 1982. Flood (Genesis). In: Bromiley GW, editor. The International Standard Bible Encyclopedia, Vol. 2. Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., p 319-321.
20. See for instance the references already cited above: Frazer; Nelson; and Woods. See also: (a) Gaster TH. 1969. Myth, legend and custom in the Old Testament. NY: Harper & Row; (b) Sykes E. 1965. Everyman's dictionary of non-classical mythology. London: J. M. Dent & Sons; (c) Thompson S. 1989. Motif-index of folk-literature, Vol. 1. Reprint of the 1955 edition. Bloomington, IN: Indiana University Press; (d) Andress R. 1891. Die Flutsagen. Braunschweig, Germany: Friedrich Vieweg und Sohn; (e) Reim JKR. 1925. Die Sintflut in Sage und Wissenschaft. Hamburg, Germany: Agentur des Rauhen Hauses.
21. See the references already cited above: Albright, p 30; Woods, p 545; Vos, p 321; Nelson, p 165; Gaster, p xxix; Frazer, Vol. 1, p 105; Filby, p 41. See also: (a) Rehnwinkel AM. 1951. The flood in the light of the Bible, geology, and archaeology. St. Louis, MO: Concordia Publishing House, p 136; (b) Rudhardt J. 1987. The flood. The Encyclopedia of Religion, Vol. 5, p 356.
22. Albright, p 30. (Note 13a)
23. Gaster, p xxxix (Note 20a).
24. Woods, p 545 (Note 10).
25. Huggett R. 1989. Cataclysms and earth history: the development of diluvialism. Oxford: Clarendon Press, p 17.
26. Thompson (Note 20).

# ARTICLES

## CORRELATION OF C-14 AGE WITH THE BIBLICAL TIME SCALE

Robert H. Brown
*Yucaipa, California*

**WHAT THIS ARTICLE IS ABOUT**

*The biblical constraints on a time scale are combined with the constraints provided by carbon-14 data in the formulation of a mathematical relationship for conversion between C-14 age and real time. This relationship is developed for convenient adaptation to varied interpretations of the biblical time constraint specifications, and is presented by an equation of exponential terms, a tabulation of useful data points, and a graph.*

### INTRODUCTION

Among individuals who have a concern regarding the validity of the historical and chronological data in the book of Genesis, there has been a desire for a reliable conversion between radiocarbon age and real-time age that extends over the full range of biblical specifications. Such a conversion would be an aid in the formulation and testing of models for earth history. The object of this treatment is to summarize the constraints to such a conversion that are provided by data in the biblical text and by C-14 age data, and incorporate these constraints into a compatible mathematical relationship.

The era with which this treatment is primarily concerned dates from the beginning of the refashioning of Earth's geology, geography, climate, and ecology that resulted from the universal catastrophe described in the seventh and eighth chapters of the book of Genesis — the Flood.

### BIBLICAL CONSTRAINTS

According to the text of the Bible that was the universal standard among Christians for the first six centuries, the Flood occurred 5352 years BP (Brown 1990). (BP refers to years before AD 1950, the zero reference time for C-14 age.) Since the Authorized Version (King James) of AD 1611 Western European Christianity has favored a biblical text according to which the Flood may be dated at 4472 BP (Shea 1979). For a treatment that encompasses both of these traditions I can take as

the biblical specification for the date of the Flood the approximation 5000±500 BP (a simplification of the straightforward 4950±450).

Some interpreters contend that the dates for the Flood given in the preceding paragraph should be reduced by 215 years. This view is based on the presumption that the Apostle Paul's statement in Galatians 3:17 overrides the testimony of Moses. Considering two statements made relatively close to an event, and speaking directly to that event (Genesis 15:13 and Exodus 12:40, 41; also quoted in Acts 7:6), to be more definitive than a passing allusion made fifteen hundred years later, I conclude that the Hebrew nation lived in Egypt for 430 years prior to the Exodus, not merely 215 years as may be inferred from Galatians 3:17. This view places Galatians 3:17 in the category specified in 2 Peter 3:16.

I prefer to place the Flood at 5350 BP, rather than the 5000 BP which I will use in the following mathematical treatment. This preference is based on the evidence that the chronological data in the fifth and eleventh chapters of Genesis as given in the scripture used by the early Christian church (the LXX) are much closer to the values specified by Moses than are those in the Masoretic text (MT) of the ninth century AD. As a set of numbers related to human genealogy, those given in the LXX are much more reasonable and internally consistent than those in the MT. The MT data in Genesis 11 are more difficult to fit into a reasonable treatment of historical data, ethnographic considerations, or C-14 data. There is substantial evidence that a source for the MT gave numbers in the fifth and eleventh chapters of Genesis that had been systematically reduced from the values in the primary source (Zurcher 1959).

What motivation could there have been for such reduction? The millennial concepts that were held among both Jews and Christians at the beginning of the Christian era (Fox 1986, p 265-267; Taylor 1855) (i.e., belief that the coming of the Messiah would occur before or at the conclusion of six millennia following creation, with a seventh millennium of universal idealistic conditions) would give determined opponents to designation of Jesus of Nazareth as the Messiah strong motivation for removal of evidence that they were nearing the close of the sixth millennium since Creation. This objective is accomplished by the difference between the MT and the LXX of about 1500 years for the time since Creation Week. Anyone who wishes to investigate this consideration more fully should consult Zurcher's treatment (Zurcher 1959). On page 42 of his monograph he says: "For about fourteen

centuries, almost all the theologians thought there had been a subtraction made by the Jews of Palestine ..."

## CARBON-14 CONSTRAINTS

Agreement of C-14 age with real-time historical age can readily be established as far back as the middle of the second millennium BC (3500 BP) (Libby 1955). Correlation beyond 4000 BP must be based on models that involve assumptions, due to lack of objects that can be precisely dated from historical records. The most successful model has been the Bristlecone Pine dendrochronology developed by C. W. Ferguson (1968). Dr. Ferguson arranged specimens of dead Bristlecone Pine wood from the White Mountains in California into an approximate sequence according to their C-14 age, and then "fine tuned" this sequence by growth-ring matching. His correlation between dendrochronology and C-14 age won reluctant acceptance from anthropologists, Quaternary geologists, and other scientists whose models had required much greater ages than were given by C-14 (Gladwin 1976, Lee 1981). The latest refinements to the dendrochronologic age versus C-14 age relationship are given by Stuiver et al. (1991). According to the dendrochronologic model there was an increasing C-14 concentration in the biosphere with increasing age beyond 3000 BP (C-14 age increasingly less than the corresponding real-time age).

Due to its characteristic complacent growth ring patterns, Bristlecone Pine wood from the White Mountains is not well suited for the development of a dendrochronology standard. This difficulty was emphasized by Dr. Ferguson in a letter to Herbert Sorensen, dated 3 March 1970, by the statement: "I am often unable to date specimens with one or two thousand rings against a 7500-year master chronology, even with a 'ball-park' placement provided by a radiocarbon date." (Sorensen 1975). There is need for a demonstration as to whether an equally good, if not better, master growth-ring sequence can be established with Bristlecone Pine specimens preliminarily arranged in a sequence of real-time age such as would be obtained from the correlation relationship developed in this paper.

The retrograde increase in biosphere C-14/C-12 ratio between 3500 BP and 7000 BP required by the Ferguson Bristlecone Pine dendrochronology reaches about 10% over the present value. A further increase up to about 50% going back to 20,000 BP has been proposed on the basis of recent dating of corals by both the uranium-thorium (U-Th) method and the C-14 method (Bard et al. 1990). In my judgment, a

correlation of real time with U-Th age has even greater uncertainty than with C-14 age.

There is increasing evidence that organic specimens which can be established confidently as fossils of material that was involved in the Flood (e.g., coal) have C-14 ages in the 40,000 year range (Brown 1988b). This constraint, together with placement of the Flood at about 5000 years BP, specifies that at the beginning of the Flood the biosphere had no more than about 1/100 of the C-14/C-12 ratio that has characterized it over the past 3500 years. (A 1/100 ratio corresponds to a C-14 age slightly greater than 38,000. An added 5000 years of real time would give such material a present C-14 age of 43,000.)

## A MODEL FOR CORRELATING C-14 AGE WITH THE BIBLICAL TIME SCALE

With the preceding background on constraints provided by the chronological data in the Bible and by C-14 data, we can now proceed to the task of correlating these constraints. The correlation developed will be an interpretation, and should be based only on fundamental data, not on other interpretations such as the Bristlecone Pine dendrochronology model or the U-Th age model. It is to be compared with these other interpretations, but to be kept distinct from them.

For the major readjustment period following the Flood we can presume that radiocarbon levels in the atmosphere may be represented by Equation 1:

$$A = A_1 (1 - e^{-at}).$$

In Equation 1, A represents C-14 level, either as the ratio of C-14 to C-12, or as C-14 spontaneous transformations per unit of time per unit mass of carbon; $A_1$ represents the equilibrium level of A; e is the base of the natural logarithms — 2.718... —; a is a parameter which is related to the rate at which A re-approaches equilibrium after a disturbance from its equilibrium value $A_1$; and t is real time measured from zero at the end of the Flood. The value of A for plant tissue will be essentially the same as for the $CO_2$ in the air from which it obtained its carbon. In animal tissue A will represent the average for the food supply which furnished the carbon in that tissue.

The large amount of organic material, and probably some of the carbonate sediment, buried during the Flood and now existing only as fossil material indicates that prior to the Flood the world inventory of C-14 was associated with a much larger amount of C-12 than has been

the case since the Flood. This is in agreement with the evidence that A for this material was about or less than 1/100 of the present value (equal to or less than $0.01A_1$). For simplification, Equation 1 treats A as having zero value at the end of the Flood. To obtain a significant comparison in the time immediately following the Flood a constant in the vicinity of 0.005, and within a range of uncertainty that might extend to 0.01, should be added to the exponent at.

The parameter a in Equation 1 is determined by the rate at which $CO_2$ is taken out of the atmosphere by the reestablishment of vegetation over the Earth's surface after the Flood, and by the cooling of the oceans associated with glaciation and the development of frigid climate zones. (The solubility of $CO_2$ in water increases with a lowering of temperature.) An effective change in the parameter a would be produced also by a *change* in the rate of formation of C-14 by interaction of cosmic rays with nitrogen in the upper atmosphere. The proportion of the cosmic rays from outer space to interact with Earth's atmosphere and produce C-14 is determined by the strength of the geomagnetic field. Fluctuations in the geomagnetic field are to be expected during stabilization following the crustal disruption associated with the Flood. A decrease in the geomagnetic field (increasing the production of C-14), or a lowering of the ocean surface temperature (reducing the amount of atmospheric $CO_2$), would contribute to an increase in the value of a.

Equation 1 is based on the assumption that the combined effect of all the factors influencing the rate at which the level of C-14 in the atmosphere changed from its pre-Flood value to its post-Flood equilibrium value can be satisfactorily represented by a first-order exponential function with a single exponential constant. To the extent to which this assumption is inadequate and there has been fluctuation of A about a smooth simple exponential trend toward an equilibrium value, there will be uncertainty in a real-time age equivalent based on Equation 1.

The relationship in Equation 1 will be easier to work with if time is measured from the present, rather than from the beginning of the post-Flood era. This is accomplished by setting t = (F-T), with F equal to a biblically based BP date for the Flood, and T representing real time BP, as in Equation 2:

$$A = A_1 [1 - e^{-a(F-T)}].$$

To evaluate the parameter a in Equation 2 we can presume A was equal to or better than $0.9 A_1$ at T equal to 4000, since C-14 ages based on interaction with the atmosphere have a better than 95% agreement

with real-time historical age over the range of T from zero to 3500. To obtain a trial value for a we can set

$$0.95\ A_1 = A_1\ [1 - e^{-a(F - T)}]$$

at T = 4000, which gives

$$e^{-a(F-4000)} = 0.05,$$

or

$$e^{+a(F-4000)} = 20;$$

from which

$$a = 2.996/(F-4000).$$

With this value for a, the activity at T years BP as given by Equation 2 becomes (3):

$$A = A_1\ [1 - e^{-2.996(F-T)\ /\ (F-4000)}].$$

Since we are not making observations at time T, but at the present (T = 0), we need an expression for the activity now (zero BP), $A_n$, of a specimen that had activity A at T years BP. After T years ago the C-14 activity will have decreased exponentially at the rate given by the mean life of a C-14 atom. For simplification we can use 8300 years for the mean radiocarbon life, since this value differs by less than ½ of 1% from the correct value 8267 (half-life 5730 years divided by the natural logarithm of 2). Accordingly $A_n = A\ e^{-T/8300}$, with A given by Equation 3. Equation 4 is:

$$A_n = A_1\ [1 - e^{-2.996(F-T)\ /\ (F-4000)}]\ e^{-T/8300}.$$

The activity now, $A_n$, is interpreted to indicate a C-14 age R by the relationship (5):

$$A_n = A_l\ e^{-R/8300}.$$

Combination of Equations 4 and 5 gives Equation 6, a relationship between T and R for a specified F:

$$e^{-R/8300} = e^{-T/8300}\ [1 - e^{-2.996(F-T)\ /\ (F-\ 4000)}].$$

Equation 6 is not useful for values of T within about ten years of a value for F, or values of R greater than about 35,000 years, because A has been inaccurately assumed to be zero for T = F.

## QUANTITATIVE CORRELATION BETWEEN BIBLICAL MODEL REAL-TIME AND C-14 AGE

For a treatment that is a median between various views of biblical chronology we can use 5000 years for F (I have already given my reasons for preferring 5350 years to be the "correct" value) to obtain Equation 7:

$$e^{-R/8300} = e^{-T/8300} [1 - e^{-2.996(5000-T)/1000}].$$

For the calculation of relations between R and T Equation 7 may be reduced to either Equation 8 or Equation 9.

$$(8)\ e^{-R/8300} = e^{-T/8300} - (3.121\times10^{-7})\ e^{+2.876T/1000}$$

$$(9)\ R = T + 8300 \ln [1 - e^{-2.996(5000-T)/1000}]^{-1}$$

(ln designates "the natural logarithm of".)

The relationship between R and T for representative values of R is outlined in Table 1. A graphical representation of these data for F = 5000 is given in Figure 1.

**FIGURE 1. Conversion plot for Real-Time Age T Versus C-14 Age R. Presumed date for the Flood set at 5000 BP real time.**

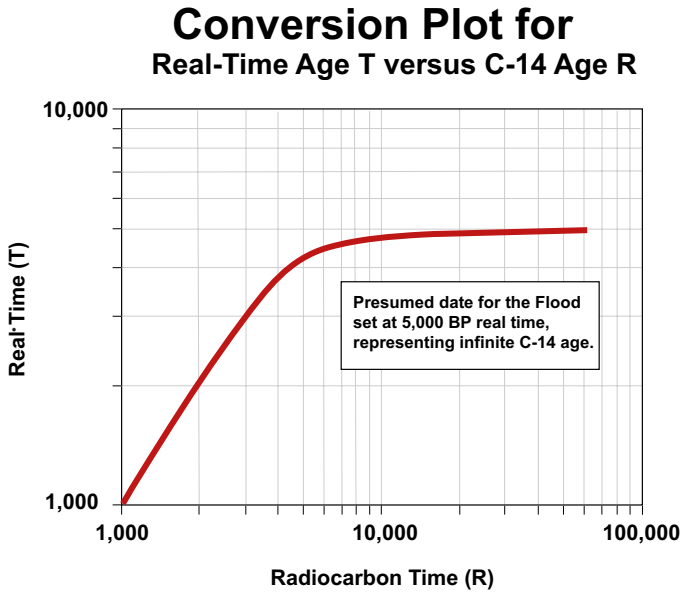


**TABLE 1. Representative Values for the Relationship Between Biblical Model Real-Time Age T and Radiocarbon Age R. The R subscript indicates assumed date of the Flood. Estimates of relationship are not warranted for values of T within about ten years of the date for the Flood, or radiocarbon ages greater than about 35,000.**

| T | $R_{5,500}$ | $R_{5,350}$ |
|---|---|---|
| 0 | 0 | 0 |
| 1,000 | 1,000 | 2,000 |
| 2,000 | 2,001 | 2,005 |
| 3,000 | 3,021 | 3,045 |
| 3,500 | 3,593 | 3,638 |
| 4,000 | 4,426 | 4,426 |
| 4,250 | 5,177 | 5,006 |
| 4,500 | 6,600 | 5,865 |
| 4,550 | 7,046 | 6,091 |
| 4,600 | 7,580 | 6,342 |
| 4,650 | 8,231 | 6,622 |
| 4,700 | 9,038 | 6,938 |
| 4,750 | 10,064 | 7,295 |
| 4,800 | 11,414 | 7,702 |
| 4,850 | 13,284 | 8,170 |
| 4,900 | 16,116 | 8,713 |
| 4,950 | 21,321 | 9,352 |
| 4,975 | 26,794 | 9,715 |
| 4,990 | 34,230 | 9,949 |
| 5,000 | (infinite) | 10,113 |
| 5,100 | ——— | 12,186 |
| 5,200 | ——— | 15,673 |
| 5,300 | ——— | 24,004 |
| 5,340 | ——— | 37,038 |
| 5,350 | ——— | (infinite) |

This conversion between C-14 age and real time resolves the enigma of the 7000±2000 C-14 age difference between hair and muscle for a musk ox carcass that was presumably frozen in Alaskan muck about 17,000 C-14 years ago (Stuckenrath and Mielke 1970). The correlation represented in Equation 7 places death of the animal in the vicinity of 4900 years ago (from C-14 age of hair), and suggests a life span within ten years of 50, rather than in the range between 5000 and 9000. Other examples of similar nature have been presented by the author previously (Brown 1987, 1988a, 1990).

## CONCLUSIONS

There appears to be a basis for a quantitative correlation of C-14 ages over the range between zero and the vicinity of 35,000 years BP with real-time ages that are in conformity with biblical guidelines. Because the buildup of C-14 in the biosphere from less than 1/100 to the full zero BP reference standard level over the time between the Flood and about 3500 BP probably did not proceed with monotonous uniformity, some anomalies are to be expected in real-time ages derived from C-14 ages by means of a mathematical model for such correlation. Since the buildup of C-14 from levels associated with C-14 ages in the mid-40,000 years range to levels associated with a C-14 age of about 35,000 years evidently occurred over only a few years of real time, correlation with real-time for C-14 ages greater than 35,000 is highly uncertain. For C-14 ages in the range between 4000 and 30,000 years the associated real-time age probably may be significantly placed within a range of less than ±100 years.

It is the hope of the author that this treatment will contribute to confidence in the biblical chronological data, and increase the effectiveness with which that data may be utilized in scientific research.

## ACKNOWLEDGMENTS

Appreciation is due Harold G. Coffin and reviewers for the improvements in clarity and effectiveness of this treatment that have resulted from their suggestions.

## REFERENCES

Bard E, Hamelin B, Fairbanks RG, Zindler A. 1990. Calibration of the $^{14}C$ timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals. Nature 345:405-410.

Brown RH. 1987. Radiometric dating from the perspective of biblical chronology. Proceedings of the First International Conference on Creationism 2:31-57. Pittsburgh, PA: Creation Science Fellowship.

Brown RH. 1988a. Implications of C-14 age versus depth profile characteristics. Origins 15:19-29.

Brown RH. 1988b. The upper limit of C-14 age? Origins 15:39-43.

Brown RH. 1990. Scientific creationism and radiocarbon dating. Proceedings of the Second International Conference on Creationism 1:43-55. Pittsburgh, PA: Creation Science Fellowship.

Ferguson CW. 1968. Bristlecone pine: science and esthetics. Science 159:839-846.

Fox RL. 1986. Pagans and Christians. NY: Alfred A. Knopf.

Gladwin HS. 1976. Dendrochronology, radiocarbon and bristlecones. Anthropological Journal of Canada 14(4):2-7.

Lee RE. 1981. Radiocarbon: ages in error. Anthropological Journal of Canada 19(3):9-29.

Libby WF. 1955. Radiocarbon dating. 2nd ed. Chicago: The University of Chicago Press.

Shea WH. 1979. Exodus, Date of. The International Standard Bible Encyclopedia, Vol. 2. Grand Rapids, MI: Wm B. Eerdmans, p 230-238.

Sorensen HC. 1975. Carbon-14 dating and the Bristlecone pines. Ministry (February), p 36-37.

Stuckenrath R, Jr, Mielke JE. 1970. Smithsonian Institution radiocarbon measurements VI. Radiocarbon 12:193-204; specifically items SI-454 and SI-455 on p 203.

Stuiver M, Braziunas TF, Becker B, Kromer B. 1991. Climatic, solar, oceanic, and geomagnetic influences on late-glacial and Holocene atmospheric $^{14}C/^{12}C$ changes. Quaternary Research 35:1-24.

Taylor DT. 1855. The reign of Christ on Earth. Chapters II and III (p 19-75), and summary of Chapter IV (p 108). Ten editions of this book were published between 1855 and 1893, some carrying an alternative title: The voice of the church.

Zurcher JR. 1959. A new analysis of patriarchal chronology. Unpublished 85-page monograph available in the Geoscience Research Institute library, Loma Linda, California, and the Andrews University Seminary library, Berrien Springs, Michigan. English translation by Antoinette Heyer.

# ANNOTATIONS FROM THE LITERATURE

## MASS EXTINCTIONS

Erwin DH. 1989. The end-Permian mass extinction: what really happened and did it matter? Trends in Ecology and Evolution 4:225-229.

***Summary.*** This paper reviews the end-Permian extinction event, which is considered to be the largest known extinction in earth history. Of Permian marine taxa, about 80% of the genera and an estimated 95-96% of the species are not found in strata above the Permian. Significant extinctions also occurred among terrestrial plants and tetrapods, especially in amphibians. There is no global iridium enrichment or other evidence for an impact at the Permo-Triassic border, and the cause of the extinctions is not clear. Global cooling has been suggested, but terrestrial fossils indicate a warming trend.

***Comment.*** The authors state that Paleozoic marine fossil assemblages are dominated by largely sessile groups, such as articulate brachiopods, bryozoans and stalked echinoderms. Mesozoic fossil assemblages are dominated by groups that were more mobile than those predominant in the Paleozoic strata. Further study of general differences in mobility of Paleozoic and Mesozoic fossil organisms might prove useful in efforts to refine Ecological Zonation Theory.

## MOLECULAR PALEONTOLOGY

Golenberg EM, Giannasi DE, Clegg MT, Smiley CJ, Durbin M, Henderson D, Zurawski G. 1990. Chloroplast DNA sequence from a Miocene *Magnolia* species. Nature 344:656-658.

***Summary.*** An 820 base pair length of chloroplast DNA was extracted from a well-preserved Miocene fossil leaf of an extinct species of *Magnolia*. This DNA was sequenced and compared with an extant species of *Magnolia*, and some other close relatives. Compared with the living species, there were 17 differences (substitutions) in the DNA, 4 of which were non-synonymous (changed the amino acid being coded for).

***Comment.*** The successful extraction and sequencing of DNA from a fossil leaf suggests it may be possible to determine DNA sequences

from other well-preserved fossils, as well as old museum skins. Results of such studies may provide information about mutation rates and may contribute to other comparative studies.

## MOLECULAR PHYLOGENY

Devereux R, Loeblich AR, Fox GE. 1990. Higher plant origins and the phylogeny of green algae. Journal of Molecular Evolution 31:18-24.

***Summary.*** Higher plants are believed to be derived from green algae. This paper reports ribosomal RNA (5S rRNA) sequences from three species of green algae. These 5S rRNA sequences have been criticized as being too short to be reliable, because they gave anomalous results. Devereux et al. state that they should be taken seriously, but not over-interpreted. In this study, higher plants should be grouped with charophytes (stoneworts). Chlorophytes (green algae) form a second group, in agreement with recent taxonomic thinking. However, one group of green alga-like organisms, the chlamydomonads, form a third, more remote group. This result differs from present theories. The *Spirogyra* sequence reported here is greatly different from that reported earlier, prompting the authors to question whether the other form was truly a *Spirogyra*.

Hedges SB, Moberg KD, Maxson LR. 1990. Tetrapod phylogeny inferred from 18S and 28S ribosomal RNA sequences and a review of the evidence for amniote relationships. Molecular Biology and Evolution 7:607-633.

***Summary.*** Similarities in ribosomal RNA sequence were investigated for 15 species of amphibians, 4 species of reptiles, and 2 species of birds. These were compared with published sequences for one species of amphibian and four species of mammals. Results showed birds more similar to mammals than to reptiles, contrary to expectations based on the fossil record. The authors cite other literature supporting this result, involving the amino acid sequences of beta-hemoglobin and myoglobin. Birds are most often grouped closest to crocodilians, a grouping supported by histone H2B sequences. Alpha-hemoglobin sequences group birds with either crocodiles or mammals, depending on the method used. Alpha-crystallin A groups birds with either crocodilians or lizards, depending on the method. Cytochrome c sequences join birds with lizards, not with mammals. Insulin sequences show some birds to be closer to alligators than to some other birds.

***Comment.*** If these results are reliable, one may question the utility of molecular sequences for determining relationships among higher taxa of tetrapods.

Li W-H, Gouy M, Sharp PM, O'hUigin C, Yang Y-W. 1990. Molecular phylogeny of Rodenda, Lagomorpha, Primates, Artiodactyla, and Carnivora and molecular clocks. Proceedings of the National Academy of Sciences (USA) 87:6703-6707.

***Comment.*** Analysis of DNA sequences from more than 30 gene portions were used to determine similarities among five orders of mammals. Rodents were determined to be the most distant from the other four orders, although the data contains considerable inconsistencies. Artiodactyla and Carnivora grouped together, but the branching diagram was bush-like for the four orders other than Rodentia and the branching sequence was uncertain. The number of differences is greater in the rodents than in the other groups, indicating the "molecular clock" does not have the same rate in all lineages.

Sogin ML, Gunderson JH, Elwood HJ, Alonso RA, Peattie DA. 1989. Phylogenetic meaning of the kingdom concept: an unusual ribosomal RNA from *Giardia lamblia*. Science 243:75-77.

***Summary.*** *Giardia lamblia*, a flagellated protozoan, lacks mitochondria, endoplasmic reticulum, or Golgi bodies. The sequence of 16S-like ribosomal RNA is so different that it is interpreted to represent the earliest-diverging lineage of eukaryotes. The extent of divergence is said to be sufficient to justify a separate kingdom, but the authors do not recommend this. Either eukaryote ribosomal RNA is more rapidly evolving, or eukaryotes are as ancient as eubacteria and archaebacteria. Ciliated protozoa are genetically as diverse as the plant or animal kingdoms.

## PALEOBIOGEOGRAPHY

Sues H-D, Olson PE. 1990. Triassic vertebrates of Gondwanan aspect from the Richmond Basin of Virginia. Science 249:1020-1023.

***Comment.*** Fossil vertebrates from Upper Triassic sediments in southern continents are generally dissimilar from any found in the northern continents. This has been interpreted as indicating a geographical separation of the southern continents (Gondwana) from the northern continents (Laurasia). Recently studied material from Virginia,

USA, includes reptiles similar to those found in Upper Triassic deposits from southern continents. This new evidence suggests that previously known Upper Triassic faunal differences between Gondwana and Laurasia may have been due to different strata being present rather than to geographical distance.

## PALEONTOLOGY

Beard KC. 1990. Gliding behaviour and palaeoecology of the alleged primate family Paromomyidae (Mammalia, Dermoptera). Nature 345:340-341.

Kay RF, Thorington RW, Houde P. 1990. Eocene plesiadapiform shows affinities with flying lemurs not primates. Nature 345:342-344.

***Summary.*** Two papers have presented evidence that fossils of the extinct mammal family Paromomyidae have been misclassified. The first paper reaches this conclusion based on a study of post-cranial bones of two genera of these Eocene fossils. The second paper reaches a similar conclusion based on a study of a recently found skull. Paromomyids had previously been classified as primates on the basis of their teeth. Both papers concluded that paromomyids are more similar to living colugos than to primates. (Colugos are nocturnal gliding mammals living in the Philippines and Southeast Asia.)

Coates MI, Clack JA. 1990. Polydactyly in the earliest known tetrapod limbs. Nature 247:66-69.

***Summary.*** Conventional evolutionary wisdom has held that vertebrates descended from an ancestor having five digits on each limb. It came as a surprise to discover that the earliest known tetrapod limbs have more than five digits. Limbs are now known from three genera of Devonian tetrapods. The number of digits varies from six in the genus *Tulerpeton*, to seven in the hindlimb of the genus *Ichthyostega* to eight in the forelimb of *Acanthostega*. The number of elements and their pattern cannot be accounted for on the basis of homology with any known fish fin, but a recent morphogenetic model is said to compare favorably with the newly discovered pattern of limb structure.

Dodson P. 1990. Counting dinosaurs: how many kinds were there? Proceedings of the National Academy of Sciences (USA) 87:7608-7612.

***Summary.*** Dinosaurs have always had a special attraction, and interest in them has increased in the past decade, due to new discoveries and the controversy over the cause of their demise. Now we have a

better idea of how many different kinds of dinosaurs there were. Dodson reduces the number of genera from 540 to 285, with 336 species. A little less than half these genera are each represented by single specimens, and skulls are unknown for about the same proportion. The most common dinosaur fossil seems to be *Maiasaura*, a hadrosaur (duck-billed dinosaur), with over 200 specimens. More than three-fourths of the genera are restricted to a single country, with the United States having the greatest number: 64 genera. Dodson estimates that the fossil record of dinosaur genera is about 25% complete, and the total number of dinosaur genera may have been between 900-1200.

## PHILOSOPHY OF SCIENCE

Mills GC. 1990. Presuppositions of science as related to origins. Perspectives on Science and Christian Faith 42:155-161.

***Summary.*** The importance of presuppositions in doing science is the subject of this paper. Mills lists four presuppositions that seem to be accepted by most scientists. These are:

1. Nature has an underlying order that can be discovered.
2. There is uniformity in nature (repeatability).
3. Sense perceptions are valid.
4. All events can be explained in terms of natural processes.

Mills accepts the first three points, but takes exception to the last one. The origin of the universe and the origin of life have not been satisfactorily explained by natural processes, and in fact appear to require processes different from those observed at present. Because of this, Mills would substitute two other presuppositions for the fourth point listed above. These two points are:

1. An intelligent cause was involved in cosmological and biological origins.
2. Nearly everything else can be explained in terms of natural processes.

***Comment.*** Mills' suggestion undoubtedly represents an improvement over the original statement that all events can be explained in terms of natural processes. However, there is plenty of room for discussion about what events might be included in the phrase "nearly everything else."

## RADIOCARBON DATING

Stafford TW, Hare PE, Currie L, Jull AJT, Donahue D. 1990. Accuracy of North American human skeleton ages. Quaternary Research 34:111-120.

***Summary.*** This paper strikes a blow in the lively debate over the age of human occupation of North America. The paper presents evidence that counters the results of carbon-14 dates which indicate a shorter human occupation. According to the authors, the accuracy of radiocarbon dating of fossil bones depends on the state of preservation of the bones. Fossil bones vary widely in state of preservation, so carbon-14 dates vary widely in their accuracy. Recent AMS dates showing no human fossils in North America before 11,000 yrs BP are therefore not reliable, in this view. Only collagenous fossils give reliable ages; non-collagenous bones give underestimates of ages. The authors suggest applying radiocarbon dating to isolated amino acid fractions from collagenous bones to improve accuracy.

## SPECIATION

Meyer A, Kocher TD, Basasibwaki P, Wilson AC. 1990. Monophyletic origin of Lake Victoria cichlid fishes. Nature 347:550-553.

***Summary.*** Approximately 200 endemic forms of cichlid fishes inhabit Lake Victoria and its satellite lakes. These forms have been variously considered to represent a small number of species with different morphs, or a large number of species, some of which are more closely related to morphologically similar species in other East African lakes. The authors report on a comparison of mitochondrial DNA sequences from fourteen Lake Victorian species, as well as species from other areas of Africa. Their results are interpreted as showing that the Lake Victorian fish are separate species, all of which have a recent common ancestor. In addition, the Lake Victorian fish are more similar to fish from Lake Malawi than to fish from Lake Tanganyika. The amount of variation in mitochondrial DNA sequence is less than is found within the human species.

## TAPHONOMY

Cutler AH, Flessa KW. 1990. Fossils out of sequence: computer simulations and strategies for dealing with stratigraphic disorder. Palaios 5:227-235.

***Summary.*** Fossil sequence can be disturbed by mixing or by reworking. Mixing occurs primarily by bioturbation, where sediments are moved by burrowing animals. Reworking occurs when sediments are eroded and redeposited. Reworking can produce a deposit containing both young and old fossils, mixed together in random order. Computer simulations were run to compare the effectiveness of mixing and reworking on fossil sequence. Mixing was found to be quite ineffective in obliterating the original fossil sequence. In contrast, reworking was found to be highly effective in destroying the order of the fossil sequence. Reworking can obliterate the fossil sequence in a deposit even if more than half the fossils are in situ and less than one-half are reworked from another deposit. Increasing sample size improves sequence accuracy after mixing, but not after reworking. Thus reworking is potentially a significant source of disorder in the fossil record.

Meldahl KH. 1990. Sampling, species abundance and the stratigraphic signature of mass extinction: a test using Holocene tidal flat molluscs. Geology 18:890-893.

***Summary.*** Inferences of the geologic causes of mass extinctions in the fossil record rely heavily on the suddenness of the mass extinctions. The most notable example is the mass extinction that occurred at the Cretaceous-Tertiary boundary. This paper attempts to use tidal flat molluscs to discover differences in extinction patterns for sudden extinction, stepped extinction, or gradual extinction.

The depths of 45 species of tidal flat molluscs were recorded to the nearest cm, and "last appearances" plotted for each species. "Last appearances" showed a gradual loss of species, with only ten of the 45 species having last appearances at the surface. About half the species had "last appearances" lower than 15 cm below the surface.

Gradual and stepped extinctions were simulated by eliminating all biostratigraphic occurrences above certain levels. The resulting patterns were compared. A graph of stratigraphic abundance vs depth of "last appearance" showed a hollow curve for sudden extinctions. For gradual extinctions, the graph was roughly flattened and without nodes. Stepped extinctions showed a series of hollow curves, each similar to the sudden

extinction graph. One conclusion is that “last appearances” are not accurately recorded in this situation unless the species is present in at least 15% of the stratigraphic sections. Another conclusion is that a sudden mass extinction would appear gradual stratigraphically, but the extinction event might be identifiable from the pattern of the distributions of stratigraphic last appearance and stratigraphic abundance.

# LITERATURE REVIEWS

*Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.*

## CLOSETS FULL OF SKELETONS

BONES OF CONTENTION: CONTROVERSIES IN THE SEARCH FOR HUMAN ORIGINS. 1987. Roger Lewin. NY: Simon & Schuster. 348 p. Cloth, $19.95.

*Reviewed by Ariel A. Roth, Geoscience Research Institute*

Paleoanthropology — the science that focuses on man's evolutionary ancestors — has long been noted for the instability of its conclusions. This volume adds another deprecating dimension to this "science": that of contention.

The author, research news editor for the journal *Science* at the time this book was written, is a well-known science writer. In this book it appears that Lewin has done his homework carefully, with extensive referencing of pertinent material and direct interviews with many of the main players.

The book is mostly a chronicle of the recent wars over hominid fossils with an attempt to analyze the reasons for so much acrimony. Lewin attributes this to a number of factors, including: 1) the personal involvement of a human studying his own evolution; 2) the passion to find new fossils; 3) the pitifully small inventory of fossils in the hands of a possessive few; 4) the influence of preconceived ideas on what one sees (in support of this he quotes anthropologist David Pilbeam: "Our theories have often said far more about the theorists than they have about what actually happened"); 5) the competition among paleoanthropologists for funds and also for designation as to who is "king of the mountain"; and 6) the subjectivity of deciding what is a valid species (in recent years the number of species in the controversy has been reduced from over 100 to about half a dozen by combining invalid species).

Lewin also reports on the Landau theory which proposes that there is a classic literary genre in the anthropological literature describing

human evolution. At Yale University, Misia Landau worked out a pattern for this genre which is based on traditional folk literature. Landau suggests that the accounts of the evolution of man follow this traditional pattern. All of this may seem foreboding for the objectivity of paleoanthropologists who are, understandably, reluctant to accept the view that they may not be purely scientific.

The main controversies Lewin reports on include: 1) the Taung Child fossil found in South Africa, at first rejected and now accepted as an important ancestor in man's evolution; 2) the Piltdown Hoax fabricated from a modern human cranium and an orangutan's jaw (one of the great unsolved whodunits of all time, it fooled scientists for some four decades while Piltdown held an honored place in man's evolutionary tree); 3) Nebraska Man based on a tooth that turned out to be from a pig-like creature; 4) the original distortions towards primitiveness in describing Neanderthal; 5) the bitter battle over dethroning *Ramapithecus* from a human ancestor to a relative of the orangutan; 6) the complex, protracted and heated controversy over the dating of a key volcanic layer associated with important remains in East Africa; 7) the recent intense controversy between Richard Leakey and Donald Johanson over the evolutionary position of the newer *Australopithecus afarensis* fossil finds; and 8) the milder conflicts in ideas as to what is considered the basic force for man's evolutionary advancement (candidates for this have changed from predation to hunting and now to cooperation).

The book is well written. The science is kept at a non-technical level and is skillfully interwoven into the historical background. It is a difficult task to ferret out the usually unpublished attitudes and emotionally charged incidents of the past, but Lewin has made a commendable attempt towards this goal. One is amazed at the revealing details he has included: e.g., shouting matches, accusations of subversion, insults, and slamming of doors. This book gives a striking picture of science at work, and the image of the cold, calm, calculating scientist is largely destroyed.

Lewin strongly emphasizes that preconceived ideas freely influence interpretations and speculation. As an example, referring to descriptions of *Ramapithecus* he states: "Here, then, was a very complete picture of an animal — not just what it looked like, but also how it lived. And all based on a few fragments of upper and lower jaws and teeth" (p 95). It should be noted that several hominid fossils including *Ramapithecus*

are now better represented than by just fragments. However, *Ramapithecus* has now been removed from the assumed evolutionary line of man and is classified as a relative of the orangutan.

The non-expert has some difficulty in trying to keep up with the ever-changing saga of man's evolution, including changes in: 1) the relative arrangement of the putative ancestors, 2) the classification of specimens, and 3) even in the characteristics of a species. For instance, Louis Leakey once changed the definition of the genus *Homo* to include a smaller-brained animal.

The "humanness" of the paleoanthropologist is reflected throughout the book. One scientist deplored Louis Leakey's attitude of viewing "his" fossils as being the important, direct ancestors to man; whereas fossils found by others were of lesser importance, being merely side branches of the human evolutionary tree. Lewin evaluates this comment as "exaggerated, perhaps, but not entirely unfair" (p 132).

Although Lewin does not disclose his personal beliefs, inferences suggest confidence in traditional scientific views. On the other hand, the author has serious questions about how man achieved superiority, including the origin of man's higher mental attributes. In a candid statement he reveals:

> *In the physical realm, any theory of human evolution must explain how it was that an apelike ancestor, equipped with powerful jaws and long, daggerlike canine teeth and able to run at speed on four limbs, became transformed into a slow, bipedal animal whose natural means of defense were at best puny. Add to this the powers of intellect, speech, and morality, upon which we 'stand raised as upon a mountain top,' as Huxley put it, and one has the complete challenge to evolutionary theory* (p 312-313).

Probably the most significant contribution of this book is not the cautions deduced from paleoanthropology alone — many are already aware of these —, but for science as a whole. Lewin feels that paleoanthropology is especially susceptible to problems of subjectivity and emotions, but these also apply to science in general. He cautions:

> *And scientists, contrary to the myth that they themselves publicly promulgate, are emotional human beings who carry a generous dose of subjectivity with them into the supposedly 'objective search for The Truth'* (p 18).

> *No science — least of all paleoanthropology — is as objective ... as is often portrayed in the philosophers' idealized view of science* (p 20).
>
> *... there is a degree of uncertainty in science that is not often made public, because it is contrary to the mythology of what science is supposed to be like* (p 235).

Science has become very powerful because it works well in many areas. It is easy to extrapolate that success into all the areas that science deals with, and be blinded to the pitfalls that lurk in the shadows. The science that deals with the past — sometimes called historical science — often deals with non-repeatable, non-testable events. It is particularly susceptible to the problems outlined in this book, but all areas of science are in varying degrees the victims of preconceived ideas.

Those who believe in creation will wonder why the biggest bone of contention of all — namely, whether man evolved or was created — is not given consideration in this book. This is a serious, but understandable, omission, since science in its present naturalistic stance does not recognize creation as a possibility. Lewin does point out that man is special and that tension is created in science when it comes to the origin of the higher mental characteristics of man. In a society such as that of the United States, where a 1982 Gallup Poll revealed that 44% of adults believed God created man within the last 10,000 years, the omission of creation can scarcely be considered casual. If it is argued that creation is not worthy of consideration, one has only to point to the plethora of unworthy information that has decked the halls of paleoanthropology for over a century to realize that this is not a valid reason. In the opinion of this reviewer, this omission reflects the bias of a science which does not allow for any possibilities beyond its own closed, naturalistic system.

While the findings of paleoanthropology in the past two decades have been impressive, especially in the *Australopithecus* realm, readers who believe in the evolution of man will not find much comfort for their ideas in this book. One is left with the distinct impression that the last chapter of the saga of man's origin is a long way off. This is a very insightful volume that should be read by anyone interested in the human dimensions of science.

# LITERATURE REVIEWS

*Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.*

## AN ARGUMENT ABOUT SCIENCE

THE ORIGIN OF SPECIES REVISITED: THE THEORIES OF EVOLUTION AND OF ABRUPT APPEARANCE. 1987-1989. Wendell R. Bird. NY: Philosophical Library. 2 vol.s. Vol. 1: 551 + xvi p; Vol. 2: 563 + xix p. Cloth, $65.00.

*Reviewed by L. James Gibson, Geoscience Research Institute*

Wendell Bird is an attorney who played a central role in the Supreme Court case surrounding the Louisiana law requiring "balanced-treatment" of creation-science and evolution in public schools. In these two volumes, Bird reviews some of the implications of the Court's decision, including its definitions of science and religion as they relate to theories of origins in general and creationism and evolution in particular. The central purpose of the book seems to be to establish a non-religious theory of origins that is compatible with Christianity. Bird names this theory "the theory of abrupt appearance." The focus of Volume 1 is the scientific evidence concerning origins. Volume 2 addresses the legal definitions of science and religion, the relationship of the theories of abrupt appearance and evolution to these definitions, and the constitutionality of teaching both theories in the public schools.

Two features of the books stand out quickly as one looks through them. The first unusual feature is the extremely large quantity of footnotes. Volume 1 contains more than 2600 footnotes that occupy more than 25% of the text. In addition to this, a major portion of each chapter consists of quoted statements linked together to form an argument. In short, the documentation is massive. The second unusual feature of the book is the presence of asterisks by the names of nearly all the scientists cited. Bird uses an asterisk to indicate that the person quoted does not advocate the theory of abrupt appearance and probably would not agree with Bird's conclusions. A warning to that effect is written at the bottom

of the first page of every chapter. This may be an attempt to avoid the criticism sometimes levelled at critics of evolution: that quotations are sometimes taken out of context and used to misrepresent the positions of the authors of those statements. It also has the effect of impressing on the reader that many of the most important objections to the theory of evolution come from those who accept much of the theory.

Volume 1 contains eight chapters. The first is introductory, and the last is a summary. The remaining six chapters are actually pairs of arguments concerning three points: the origin of biological diversity, the origin of life, and the origin of the universe. Each topic is addressed by two chapters. The first chapter of each pair presents empirical evidence in favor of the theory of abrupt appearance; the second presents the conjectural nature of evolutionary theory on the point under consideration. Each chapter begins with an introduction and ends with a summary. By the time one has read the introductory chapter, each chapter with its introduction and summary, and the summary chapter, he should have become thoroughly exposed to the arguments presented.

In Chapter 1, Bird attempts to describe the theory of abrupt appearance in scientific terms. He is very careful to emphasize the distinction between the theory of abrupt appearance and any particular religious belief in a creator or God. Chapter 2 is an argument that the scientific evidence suggests the possibility of abrupt appearance of the various living lineages. The familiar characteristics of gaps, stasis in the fossil record, and abrupt appearances are described. Information content, probability, limits to change, and taxonomy are all used to argue for abrupt appearance. Chapter 3 describes some of the problems with the evolutionary theory of continuity among living organisms. The failure of any plausible theory of macroevolution and the gaps among natural groups are cited as evidence against evolution. At over a hundred pages, this chapter seems too long.

Chapters 4 and 5 respectively advocate the abrupt appearance of life and refute the evolutionary explanation for the origin of life. Information theory, laws of probability, thermodynamics, and various biochemical difficulties are discussed. The results of laboratory attempts to test the hypothesis of abiogenesis are described and evaluated.

Chapters 6 and 7 respectively describe evidence for the abrupt appearance of the universe, and evidence against the evolutionary hypothesis of the big bang. Among the arguments presented are the presence of hydrogen (indicating that the universe is not infinite in

age), the great information content of the structure of the universe, the uneven distribution of matter in the universe, the presence of radiohaloes in granitic rocks, and the discordant red shifts of associated galaxies.

Volume 2 compares the theories of evolution and abrupt appearance with respect to their scientific basis, their religious or non-religious nature, their educational value, and the constitutionality of their presentation in public schools.

In Chapter 9, Bird discusses some of the difficulties in defining science precisely. Judge William R. Overton's decision in the McLean case involving the Arkansas "balanced-treatment" act is especially singled out for criticism. Several anti-creationist scientists and philosophers are quoted in support of Bird's position that the judge's definition of science was at best inaccurate, and at worst deliberately contrived to exclude creationism. In Chapter 10, Bird defends the proposition that regardless of which definition of science is used, both creation and evolution meet the definition equally. Chapter 11 is a short discourse on whether abrupt appearance, creation, or evolution are the only scientific alternatives to explain the origin of the universe and life. Bird concludes that they are the only alternatives, but that the theory of abrupt appearance does not depend upon this fact for its support.

In Chapters 12-15 the religious or non-religious nature of the theories of abrupt appearance and evolution is discussed. Chapter 12 contains a brief discussion of the definition of religion. In Chapter 13, Bird argues that: a) the term "creation" is frequently used in a non-religious sense, b) reference to a creator is not required by either theory under discussion, c) the two theories are parallel in their sometime-reference to a creator, d) reference to a creator does not necessarily imply any particular religious belief about that creator, and e) both theories are linked to world views that may be compatible with various religious beliefs. In Chapter 14, Bird argues that the consistency of a theory with a religion does not make the theory religious, and that both theories of abrupt appearance and evolution are parallel in being consistent with religious beliefs, although neither theory is itself religious in nature. In Chapter 15, Bird shows that *both* theories have been supported by religious as well as scientific arguments, and that creation has been supported by scientific arguments more often than by theological arguments. In Chapter 16, Bird argues that evolutionists have been more active politically in repressing the teaching of creation than

creationists have been in promoting it, with many creationists even not supporting the mandatory teaching of creationism. in the public schools.

Chapters 17-18 evaluate the educational effects of considering the theory of abrupt appearance together with the theory of evolution. In Chapter 17, Bird argues that consideration of alternative hypotheses is educationally beneficial in that it teaches students to analyze and make comparisons. Other benefits derive from the possibility that minority viewpoints may someday be recognized to be correct, and that exposure to various views should increase respect for the views of others. Bird points out in Chapter 18 that a widespread anti-creationist and anti-discontinuitist bias exists within the evolutionary community. This bias essentially prevents those with discontinuitist views from attaining important positions in the scientific community or from presenting their views in scientific journals. In some cases, such discrimination influences the acceptance of students into graduate programs, or the success of the students in completing their studies.

Chapters 19 and 20 consider the constitutionality of teaching alternative theories of origins in the public schools. In Chapter 19, Bird discusses the rights of students to learn and the rights of teachers to present alternative viewpoints. Several court decisions are cited in support. In Chapter 20, Bird argues that the teaching of creationism could be done in such a way that it would not violate the U.S. Constitution, and that Judge Overton's opinion was seriously flawed in the Arkansas balanced-treatment act. Moreover, teaching the theory of abrupt appearance would not violate the U.S. Constitution, but would promote student welfare by presenting alternative views and developing critical thinking.

The final chapter of the book summarizes the arguments of the second volume.

Bird's presentation of the theory of abrupt appearance is beneficial in that it: a) maintains the U.S. Constitution's requirement for separation of church and state, b) provides alternative views of origins for children, and c) demonstrates the nature of scientific inquiry through use of multiple hypotheses. If such an approach to origins could be implemented in public-school science classes, it would enhance the ability of children to make critical comparisons and to think for themselves.

# LITERATURE REVIEWS

*Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.*

## TESTING TIME

ABSOLUTE AGE DETERMINATION. 1990. Mebus A. Geyh and Helmut Schleicher (English translator: R. Clark Newcomb). NY: Springer-Verlag. 503 p. Cloth, $69.00.

*Reviewed by R. H. Brown, Yucaipa, California*

This book fills a long-felt need for a comprehensive and authoritative summary of all physical and chemical techniques for quantitative determination of age. In their Introduction (p 1), the authors state: "This book is meant to be both a textbook and a reference book of all methods of physical and chemical age determination." In the preface (p vi), the reader is informed that the book "is addressed to everyone interested in the application of physical and chemical dating methods to the geosciences and archaeology. It should be especially valuable as a concise but comprehensive reference for students and practitioners using these methods."

For each technique the reader is given an explanation of the scientific principles involved, the materials and time range for which the technique is best adapted, key literature references concerning the technique and its application, and illustrative examples of its use. The literature references take up 64 pages of fine print. The text is written so that readers who do not intend to set up or operate a dating laboratory can skip over the Sample Treatment and Measurement Techniques section of each discussion.

The book treats a total of 56 distinct techniques for absolute-time-interval determination based on fundamental processes which characterize elementary matter. Consideration is given to an additional 15 techniques which are based on chemical reaction rates and cycles resulting from global events. A fold-out at the end of the book lists these 71 techniques, together with summary statements concerning the materials to which they are adapted, the time range of their application, and their suitability rank.

Against a background of implicit general confidence in the prevailing long-age models for the history of the universe, the Solar System, and planet Earth, the authors endeavor to take a critical approach to the

evaluation of each technique they discuss. In their Preface (p vi) they state:

> *It is...becoming increasingly difficult to assess the meaning of the data obtained; for example, the question may arise whether the determined age is the age of formation, early or late diagenesis, or some stage of metamorphosis. Moreover, different components of a sample may yield different kinds of ages, depending on the method applied....The information provided by the absolute dates alone is not sufficient to make chronological sense. This information must be supplemented by* [additional consideration before a reasonable interpretation can be developed].

An illustration is provided (p 6) by "U/Th dates for speleothem that are less than l0ka [and] often prove to be too large by many thousands of years without any indication...that such is the case."

From the viewpoint of most readers of *Origins*, the authors' repeated emphasis on need for age data to be *interpreted* by an *experienced* geochronologist (p 7, 22, e.g.) may be taken to indicate that in some cases valid interpretation(s) other than that which is currently in fashion may be possible. In Chapter 4 ("Treatment and Interpretation of the Raw Data") they state:

> *... each radiometric 'age' is never more than an analytically determined parameter (date) which can provide information about the time of a specific geological event only when all known geological, petrographic, and geochemical aspects are included in the interpretation. It must also be kept in mind that not all of the possible effects of the geological processes on the various dating methods can be completely understood or even recognized* (p 12).

In Chapter 6, which treats radiometric dating methods and extends over 263 pages, it is pointed out (p 55) that *if* a sample has been isolated (i.e., has been a closed system) its K-Ar "age" may designate initial crystallization, cooling, sedimentation, or diagenesis (changes in a sediment after initial deposition), and that this "age" may be unrealistically *low* because of greater argon diffusion than expected at low temperatures (even several orders of magnitude faster), or excessively *high* because radiogenic argon that previously accumulated in the material (by either diffusion or in-situ radioactivity) was not driven out before recooling (p 62).

In 35 pages of discussion on techniques that utilize a measurement of radiogenic lead, seven techniques are treated. Designating by "t(isotope

ratio)" the radiometric time (age) determined from a particular isotope ratio measurement, the usual pattern from measurement of a specific specimen is $t(^{207}Pb/^{206}Pb) > t(^{207}Pb/^{235}U) > t(^{206}Pb/^{238}U) > t(^{208}Pb/^{232}Th)$. This discordance implies either secondary Pb loss or gain in U and Th (p 117). In many cases the discordant data can be interpreted satisfactorily in terms of an initial formation time (age) $t_0$ and a subsequent modification event at $t_1$.

The reader of this review must not get an impression that radioisotope ages are characteristically discordant and of questionable interpretation. The frequency with which different isotope systems yield equivalent ages for a specimen is impressive. Examples include: the 3.59 Ga (giga or $10^9$ year) age for the Amitsoq Gneiss of Greenland, according to Lu/Hf, Rb/Sr, and U/Pb isotope ratios (p 110), and the 2.72 Ga age for the Archean komatite flows in Ontario according to Re/Os, Sm/Nd, and Pb/Pb isotope ratios (p 113).

The 15 pages of discussion in Chapter 6 on the dating of meteorites and lunar rocks provide convenient access to the uniformitarian concepts concerning the history of elementary matter in the Solar System and the Milky Way Galaxy. A particularly significant observation treated in this section is that "Nearly all meteorites have been found to have a solidification age within the narrow limits of 4.57±0.03 Ga" (p 307; see also p 86 and 144), according to Rb/Sr, Re/Os, Sm/Nd, $^{207}Pb/^{206}Pb$, U/Pb, Th/Pb, and fission-track dating methods.

In their discussions of dating techniques based on recovery from disequilibrium, on the effects of radioactive transformation, on chemical processes, and utilizing paleomagnetism, the authors are thorough in pointing out the large uncertainties involved (p 253-371).

The text is notably free of typographical and grammatical errors. Most of those encountered are spelling errors due to loss of one letter in the typesetting process. The English translation is generally excellent, but there are a few difficult sentences which betray the problems of translation.

On p 125 the text incorrectly uses Ma (million years) for numbers which specify Ga (giga or billion years), or incorrectly uses a decimal point when specifying ages in Ma.

In the discussion on correction of Carbon-14 ages for contamination, Equation 6.62 on p 174 appears to be incorrect (wrong sign on one term?), but the associated Figure 6.55 is evidently correct.

Most readers of *Origins* approach a consideration of physical and chemical age dating with a concern regarding the relationship between the results obtained and the chronological data given in the Bible. In my judgment the raw physical data obtained from our observations of the

physical operation of the universe should be considered as revelations of the deity, and should be considered together with the specifications conveyed in the inspired writings of the Bible. The challenge is to find interpretive models that do not violate either sound basic scientific principles or sound principles of exegesis. Each source of information should illuminate the other. Scientists who are acquainted with the data treated in this book should not be expected to listen to a treatment of biblical material that does otherwise. For example, the $^{87}Sr/^{86}Sr$ data from marine carbonates discussed on p 93 could indicate volcanic activity during the global upheaval referenced in Genesis 7 and 8, with activity building up to the end of the "Jurassic," and declining sharply during the "Cretaceous" and into the early post-upheaval period.

A treatment of physical age data that harmonizes with the historical data in the Bible and is also as persuasive as the long-age interpretations given in this book will probably never be developed. The basis for my confidence in making such a prediction is the extreme improbability that there will be a sufficient number of individuals with adequate information and adequate financing coordinated for development of models that incorporate biblical specifications to the same degree of their potential that models which contradict biblical specifications have been developed to their potential.

There probably are few, if any, individuals who have developed implicit confidence in biblical testimony solely on the basis of supporting evidence from the natural sciences. But confidence in the character of God, and in the universality of truth, requires confidence that models can be developed which coordinate observations from the natural sciences with the witness of inspired testimony in a manner that meets the highest academic standards for interpreting each. In the search for truth there should be scientifically minded individuals who have the humility to recognize that some incorrect interpretations of physical data might be identified by specifications in the Bible, and there should be religiously oriented individuals who have the humility to recognize that some cases of reading more into the Bible than its Author and writers intended to convey might be identified by data acquired through scientific investigation. Models that harmonize both sources of specification do not need to be the most popular, or be widely accepted; but they must be true to the full range of evidence and to sound principles of interpretation. Geyh and Schleicher have given us a valuable resource for progress on the development of such models.

# GENERAL SCIENCE NOTES

## THE IMPLICATIONS OF THE OKLO PHENOMENON ON THE CONSTANCY OF RADIOMETRIC DECAY RATES

*By C. L. Webster, Jr., Geoscience Research Institute*

Unless there are unusual (external and/or internal) pressures compelling an individual to question the constancy of radiometric decay rates, they are considered to be constant, with little reason for questioning.

The usual source of pressure causing an individual to question the constancy of the decay rates is one's own personal philosophy. Scientifically speaking, radiometric decay constants, once measured, remain unchanged except for minor adjustments due to the refinement of measurement techniques. However, a candid question to ask would be: "Is there any hard physical evidence that would corroborate the large magnitudes of the decay rates apart from laboratory studies?" I believe that the answer is "Yes!" In addition to the radiohalo evidence found in various rock formations throughout the world (Brown 1990), the Oklo Natural Reactor Phenomenon, found in Gabon, Africa, contributes meaningful insight into the evaluation of radiometric decay rate constancy.

In June, 1972, a routine isotope analysis for U-235 content of uranium ore from Gabon, Africa, revealed a significant deviation from the standard $0.7202 \pm 0.0006\%_a$ U-235 (atom per cent). The initial atypical analysis was $0.7171 \pm 0.0010\%_a$ U-235. Further analyses revealed U-235 concentrations as low as $0.621\%_a$, with one core analysis exhibiting a low of $0.440\%_a$. These analyses were systematically traced to the Oklo mine of the Franceville Uranium Mines Company in Gabon, Africa. Once the deviant ore was traced to its source, additional analyses produced one sample with a phenomenal low of $0.292\%_a$ U-235 (Naudet 1974). The only reasonable explanation for this depletion of U-235 was an ancient sustained nuclear chain reaction within the ore formation. The possibility of a natural reactor occurring had been proposed as early as 1956 (Kuroda 1956).

If uranium containing the natural $0.7202\%_a$ concentration of U-235 is used as the fuel, a sustained nuclear chain reaction is possible only under severe artificial geometric constraints of alternating uranium and

moderator, or with unique neutron moderation by deuterium (Canadian natural-uranium "CANDU" power reactor). Neither of these conditions are possible under the normal conditions found in nature, nor has evidence for such conditions been found at the Oklo site. Therefore, the conditions of criticality there must have been different from those currently present. The most probable set of conditions for a sustained nuclear reaction attainable under natural conditions at Oklo would involve neutron moderation by ordinary light water.

Before a sustained nuclear chain reaction with moderation by light water is possible, there must be an enrichment of U-235 to about $3\%_a$. Operating under the assumption that the decay constants for uranium have remained constant over geologic time, the U-235 concentration would be approximately $3\%_a$ about $1.45\times10^9$ years ago (less than three half-lives of U-235). In other words, if the present laws and constants of nature had extended throughout the past, the Oklo uranium deposit could have become critical about 1.45 billion years ago, if all other necessary conditions were met at that time. Is there any physical evidence to suggest that such might have been the case?

The natural fission reactor problem has been approached from three different perspectives: 1) Rb-Sr techniques for determining the age of the formation in which the Oklo deposits are located; 2) determination of the radiogenic lead in the Oklo deposits; 3) measurement of the ratio of fission products to the present concentration of U-235, and comparison of these ratios with the neutron flux that would have been associated with any decrease in U-235 by natural fission.

The Oklo uranium deposit is located in the middle Precambrian Francevillian formation. Associated pelites (clay-like rocks), microsyenites (igneous type of minerals) and volcanic rocks were dated using both Rb-Sr and K-Ar techniques. Interstratified rhyolitic tuffs (also volcanic) were also analyzed. Concordance was found for all techniques and all materials at 1,740±20 million ($1.740\pm0.020\times10^9$) years B.P. (Naudet 1974). Such concordance for independent radiometric methods and non-related mineralogy cannot be lightly dismissed.

Difficulty was experienced when attempts were made to date the ore deposit within the reactor sites by lead/lead and uranium/uranium isotope ratios. However, for the ore zones outside the natural reactor sites the majority of analyses by these same techniques resulted in ages between 1,750 and 1,800 million years B.P. Ion microprobe analyses of individual uranium mineral grains from these ore zones revealed an age

on the order of 1,700 to 1,800 million years B.P. (Naudet 1974). It should be emphasized that all of these ages are exclusively dependent upon radiometric half-life data and the presumed constancy of radiometric half-lives throughout time.

Fission products exhibit unique isotopic signatures that are entirely different from the naturally occurring isotopic signatures. Utilizing these differences researchers have not only identified the isotopes undergoing fission, but also the determined percentages of each that has been fissioned. In addition to isotopic signatures, the relative initial abundances of each element present before the nuclear reactions occurred have also been determined.

Application to the Oklo data of the isotopic systematics developed from current reactor theory reveals a remarkable fit of theory with field data. In almost every elemental isotopic signature analyzed, with respect to a U-235 concentration at the present value of $0.7202\%_a$, the fission products were found in concentrations exceeding the predicted values by a factor of about six (5.8). On the other hand, if the initial concentration of U-235 is assumed to be about six times greater than its present concentration, the concentrations of fission products found within the Oklo reactor closely match theoretical values, within experimental error (Naudet 1974).

The isotopic studies of neodymium provide strong supporting evidence for a natural occurring self-sustained nuclear-fission reactor at Oklo. Figure 1 illustrates the isotopic signature of the seven stable isotopes of naturally occurring neodymium. The isotopic signature of neodymium from U-235 fission is illustrated in Figure 2. Note the distinct absence of the Nd-142 isotope and the relative abundances of the 143, 144, and 145 isotopes as compared to those of the natural neodymium. The isotopic signature for the neodymium found at the Oklo reactor site is illustrated in Figure 3. The presence of a 142 isotope is indicative of the existence of natural neodymium prior to the reactor going critical. In order to compare the Oklo reactor neodymium with that of fission neodymium, the Oklo signature must be corrected for the presence of the natural neodymium. This is done by calculating the absolute abundances of each isotope 143, 144, 145, 146, 148, and 150, based on the absolute abundance of the Nd-142 isotope, and subtracting these from the Oklo signature. Once this is completed the corrected isotopic signature can be determined (illustrated in Figure 4). Without a doubt, the corrected

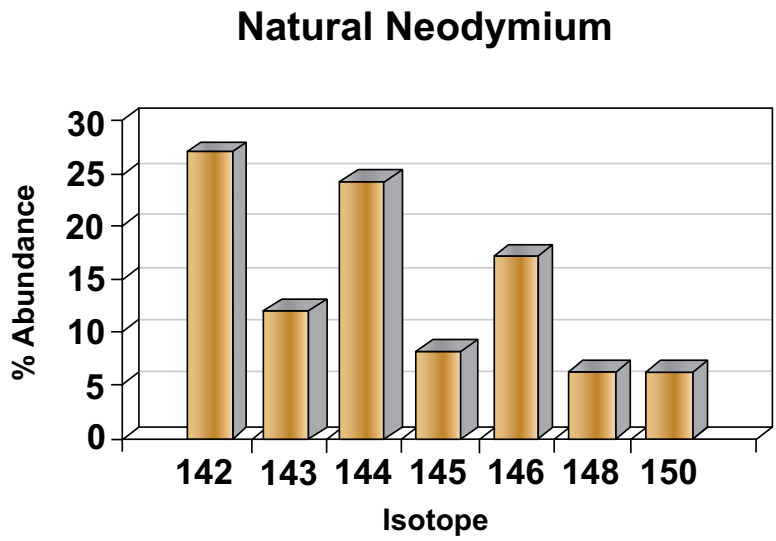
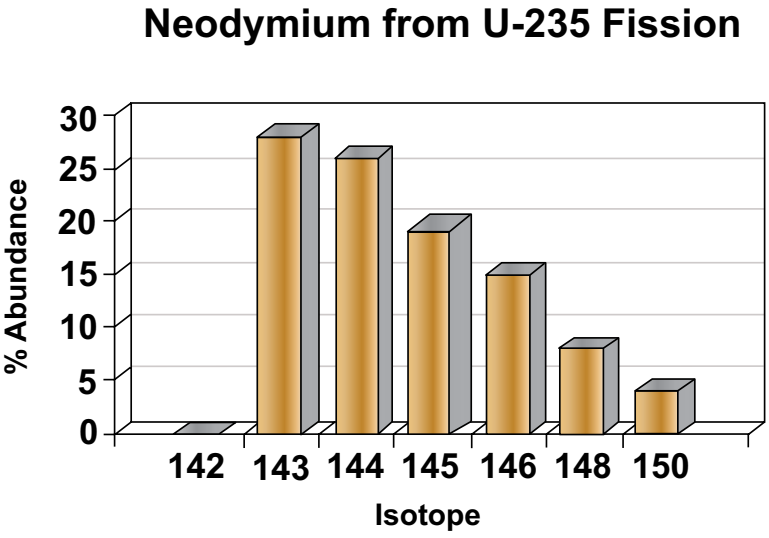



**FIGURE 1. Isotopic signature for naturally occurring neodymium.**

**FIGURE 2. Neodymium isotopic signature from the reactor fission of U-235.**



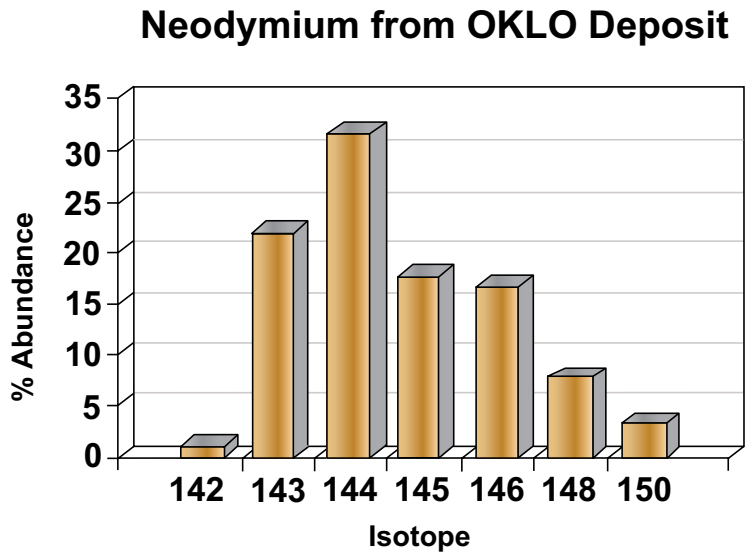
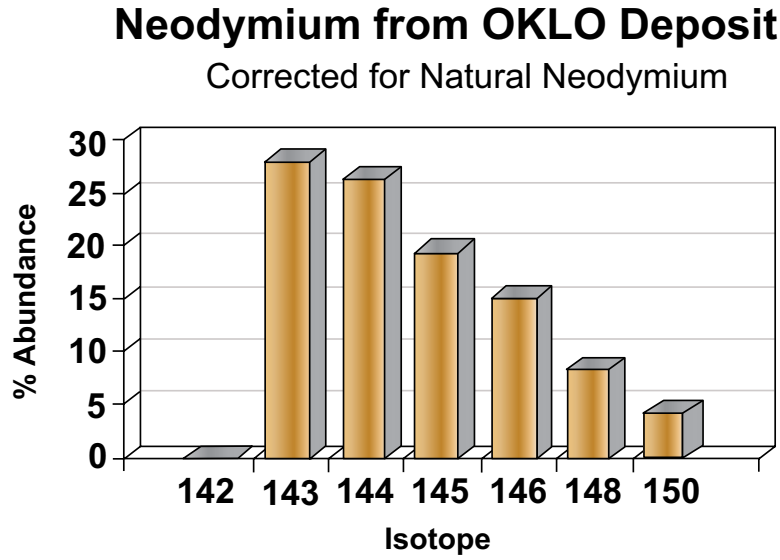



**FIGURE 3. Isotopic signature for neodymium isolated from the Oklo natural reactor site in Gabon, Africa.**

**FIGURE 4. Oklo reactor neodymium isotopic signature corrected for the presence of naturally occurring neodymium.**



Oklo neodymium signature is the signature for that of neodymium from the fission of U-235.

In addition to corroborating the fact that the Oklo deposit did become a natural reactor, the absolute abundances of the neodymium isotopes also substantiate the fact that the U-235 concentration, at the time of criticality, had to be on the order of $3\%_a$ (Naudet 1974). This is the hard non-radiometric decay data needed to support the large magnitudes and constancy of the radioactive decay rates.

Initial modeling suggests that the Oklo reactor went critical, during the Precambrian, approximately 1.7 to $1.9\times10^9$ yr ago, and that the period of duration was at least $2\times10^5$ yrs (Naudet 1974, Cowen et al. 1975).

A question that now arises in the face of these strong data supporting long ages for the existence of abiotic matter is, "Can these data be accepted within the Scriptural framework of a literal seven-day creation as described in Genesis?" I personally believe that the answer is "Yes!"

One of the immediate consequences of accepting these long ages for the abiotic material of the earth is the assumption that this matter existed on planet Earth before the creation of life. This assumption is supported by interpreting Genesis 1:1-2 as identifying God as the Creator of the "foundations" of the Earth, regardless of when that creation process took place. The creation of life and living processes, as we know them, begins with verse 3 of Genesis 1. In addition, one can add the fact that there is no specific reference in the scriptural account of Creation week that addresses the creation of water or the mineral components of dry land ("earth" that was created on day three). The only reference made to their creation is "in the beginning." It seems possible then that the elementary abiotic matter is not bound by the limited age associated with living matter.

The implications of this approach would suggest that the radiometric clocks are not reset to zero whenever the minerals are transported by igneous or erosional processes. This approach also strongly suggests that the radiometric age assigned to the inorganic minerals associated with a fossil is more a reflection of the characteristics of the source of this inorganic material than an indication of the age of the fossil.

Conflicts between scientific and biblical interpretations are minimized with these assumptions. However, not all of the questions are answered, and areas that call for the exercise of faith remain.

In seeking to harmonize the revelation of God through Scripture and natural science, we must find a model that is consistent with *both* sources of revelation. Where such consistency is not found, we need to seek a better understanding of both sources through the guidance of the Holy Spirit.

## REFERENCES


Brown RH. 1990. Radiohalo evidence regarding change in natural process rates. Creation Research Society Quarterly 27:100-102.

Cowan GA, Bryant EA, Daniels WR, Maeck WJ. 1975. Some United States studies of the Oklo Phenomenon. International Symposium of the Oklo Phenomenon, Libreville, Gabon, l'Agence Internationale de l'énergie Atomique SM-204(5):341-356.

Kuroda PK. 1956. On the nuclear physical stability of the uranium minerals. Journal of Chemical Physics 25:781-1295.

Naudet R. 1974. Commissariat á l'Energie Atomique (France), Le Phénomène d'Oklo. Commissariat á l'energie Atomique, Bulletin d'Informations Scientifiques et Techniques 193(June):7-45.