The Sands of Time:
A Biblical Model of Deep Sea-Floor Sedimentation

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Abstract

Modern evolutionism requires that the earth be very old. One line of evidence cited is the length of time required to deposit the observed thickness of sea-floor sediments far from any direct continental source. Using the low current depositional rates results in a minimum age of tens of millions of years. The model of deposition presented in this paper differs from the conventional model primarily in the rate of deposition, which is asserted to have peaked at an enormous level during and after the biblical Flood and is presumed to have fallen at an exponential rate to the present low level. Because biblical evidence strongly supports a short historical period between the Flood and the present, the shape of the decay curve is very steep. Data from the Deep-Sea Drilling Project (DSDP) were reinterpreted for this paper. By estimating the thickness of sediment corresponding to this interval and asserting a set of boundary conditions, an analytical model is presented that estimates the age of sediment from a particular depth at a given borehole

If the modern evolutionary model of deposition is correct, the water temperature evidenced by fossils would show only small, random variations. If a catastrophic event such as the Flood occurred, temporary warming of the water immediately after the catastrophe should have occurred and may be detectable. Fossil evidence of water temperature at the time of deposition is believed by some researchers to correlate with the ratio of oxygen isotopes of mass 16 and 18. Because foraminifera are common in both present-day and ancient sediments and contain oxygen in their carbonate skeletal remains, they are often analyzed for the oxygen isotope ratio and an inferred water temperature is calculated. Based on DSDP data from selected boreholes, and plotted on a timescale modified by the analytical model derived in this paper, a general cooling trend appears plausible from the limited dataset.

Keywords

Sea-Floor Sediments, Depositional Rates, Deep-Sea Drilling Project Data, Sediment Thicknesses, Boundary Conditions, Analytical Models, Water Temperatures, Foraminifera, Oxygen Isotopes, Cooling Trend, Age Estimates

Introduction

Near the mouth of a muddy river flowing into the ocean, it is common knowledge that sediments transported by the river slowly settle out of the water and form deposits on the sea floor. In some locations, such as the delta regions near the mouth of the Mississippi River or the Nile River, the build-up of sediments has resulted in the addition of large regions of new land. However, it is less well known that the growth, death, and deposition of microorganisms in the deep ocean have contributed to the formation of sea-floor sediments, particularly in mid-ocean regions. These microorganisms make up the bulk of what is called plankton. Sediments, derived from rock (lithogenous) and various life forms (biogenous), accumulate on the ocean floor and form a record of earth history. If the characteristics of the sediments can be related to events and processes which supplied the sediment, they can be a valuable tool to study earth history.

Scientific research on sea-floor sediments has been actively pursued for over two hundred years with a concentrated emphasis during the past forty. Sediment cores have been extracted from the sea floor at locations throughout the earth and analyzed for types of lithogenous material, types of biogenous forms, sedimentation rate thickness, date of accumulation, and many other interesting features. One of the most interesting fields of research has been the study of paleoclimates using the measurement of oxygen isotopes in the tests from types of microorganisms called foraminifera. This specialized field has developed an explanation for climate fluctuations from warm periods in the Cretaceous, when dinosaurs are thought to have roamed the earth, to cold periods, such as the recent "Ice Age." Strong attempts have been made to explain the cyclical layering of sediments as caused by periodic occurrences of "Ice Ages" caused, in turn, by orbitally-induced fluctuations in solar heating of the earth.

The time frame offered by the conventional explanations of climate suggest that the ocean sediments accumulated over tens of millions of years, and recent "Ice Ages" occurred over periods of time on the order of 100 millennia. These ages are not compatible with a literal interpretation of the biblical account of creation and earth history. The main sources of disagreement between the conventional model of earth history and a model consistent with the Bible for sediment accumulation are the assumptions about the magnitude of the driving mechanism and the process rates. The conventional model assumes sediment accumulated slowly over long periods of time by low-energy processes. The creation model, to be developed in this paper and with more supporting documentation in Vardiman (1995), assumes most of the thick sedimentary layer on top of the continental basement and underwater accumulated rapidly over a relatively short period of time by catastrophic processes during and following the global Flood described in Genesis.

Biblical Time Constraints

The Bible does not speak directly about sea-floor sediments or foraminifera. Nowhere do the Scriptures describe the vast layers of sediment which cover the ocean floor, nor do they discuss the processes by which they were formed. Scripture contains only brief, general references that discuss the creation of the sea and God's control over its devastating power. Yet, it is evident that if a global Flood occurred as described in Scripture, catastrophic events would have occurred in the ocean and massive quantities of sediments would have been produced and distributed over the continents and the ocean floor. Some sediments may have originated on the third day of the Creation week when the continents were separated from the oceans, as described in Genesis 9, 10. However, it is likely that most of the sediments were produced during the Flood.

The Flood is described in Genesis 7 primarily in relation to the destruction of life upon the earth. God's concern centers around man. However, if " … every living substance was destroyed which was upon the face of the ground …" and "… all the high hills, that were under the whole heaven, were covered …," it is logical to assume that major devastation to the crust of the earth occurred as well. The Scriptures do not address these effects, but if one accepts the biblical account that a global Flood occurred, then the geologic evidence over the earth bears silent testimony to the destructive power of the Flood event.

The conventional old-earth model assigns an age of about 65 million years BP to the end of the Cretaceous period. A literal interpretation of Scripture would suggest that the origin of planet earth occurred quite recently—much less than 65 million years ago. The recent-creation model, which I will use assumes God created the world in a supernatural creative event some 6,000 years ago, and judged His Creation through a worldwide catastrophic Flood some 4,500 years ago. The assumption that the Flood occurred about 4,500 years ago is derived from Ussher (1786) using the Textus Receptus. Some would choose a longer chronology based on the Septuagint and relaxation of additional time constraints (Aardsma, 1993). However, the author prefers this time frame, at least to start the study. Between God's supernatural interventions in the affairs of the world, He normally allows the physical processes to operate according to the laws of science. We wish to determine whether the sea-floor sediment data can be reasonably explained within this conceptual framework.

Thickness of Sediments and Accumulation Rates

The occurrence of a global Flood, as described in the Bible, would have produced layers of sediment on both the continents and the sea floor. Many of these sediments would have been deposited rapidly during and immediately following the Flood. After the Flood, as the frequency and intensity of the tectonic events subsided (Wise et al., 1994), the rate of lithogenous sediment deposition would have decreased in proportion to the decrease in tectonic activity and in proportion to the re-establishment of vegetative cover. Because the oceans would have been well-mixed by the Flood and probably warmed somewhat by the energy released from frictional forces and heat from magma, brines, etc. brought up from deep within the earth associated with "… all the fountains of the great deep …" (Genesis 7:11), as well as volcanism, it is likely that biogenic sedimentation would have increased after the Flood for some time until the nutrients were depleted. As the nutrients were depleted and the ocean cooled and stratified, the biogenic sediments would have decreased with time.

The functional change in sediment formation after the Flood is unknown. However, it is reasonable to assume an exponential decrease in tectonic activity and, consequently, an exponential decrease in sedimentation. It is commonly found in geophysical phenomena that a sudden pulse in activity (earthquake frequency, volcanic activity, rate of erosion, sediment deposition, etc.) is often followed by an exponential decrease in intensity and/or frequency. An exponential function decreases by 63% over a given period called the relaxation time. For example, if the sea-floor sediment deposition rate was 100 cm/year at the end of the Genesis Flood and the relaxation time was 500 years the deposition rate would be only 37 cm/year, 500 years after the Flood. One thousand years after the Flood the deposition rate would decline further to 14 cm/year, etc. The relaxation time is determined by the characteristics of the physical system and is generally defined as the time interval required for a system exposed to some discontinuous change of environment to undergo 1/e (e = 2.718 …) of the total change of state which it would exhibit after an infinitely long time. A refinement to the assumption of an exponential decrease in deposition may need to be made later by treating the accumulation of lithogenous and biogenous sediments separately. For now, a simple exponential decrease, irrespective of type, will be assumed.

The current accumulation rate for sediment formation in the deep ocean has been measured extensively. The rate appears to vary between about 1 cm/1,000 years to about 10 cm/1,000 years, depending on the investigator and location on the earth. The rate is so small that direct measurements are difficult. In addition, corrections must be made to account for dissolution and other effects. Traps are positioned at various levels in the ocean to collect samples of sediments as they drift downward from biogenous and lithogenous sources. For calibration purposes a uniform accumulation rate is assumed and the observations are compared with the upper layers of sediment formed over the past few hundred years. Since the conventional interpretation of sea-floor sediment accumulation requires at least tens of millions of years for the formation of the observed layers, it is likely that the average accumulation rates quoted are biased to small values. Nevertheless, the model developed here will assume today's average accumulation rate of deep sea-floor sediment is 2 cm/1,000 years or 2×10^{-5} meters/year.

The thickness of sea-floor sediment accumulated since the Flood is unknown. It is unclear how much of the sediment was formed during the energetic events of the Flood and how much formed later as the effects of the Flood subsided. There is no uniformity of opinion among creationists as to the location of the boundary between pre-Flood and Flood rocks on the continents, let alone between Flood and post-Flood strata on the ocean floor. For example, some creationist scientists believe the boundary between pre-Flood and Flood rocks in the Grand Canyon occurs between the Vishnu Schist/Zoroaster Granite and the Tapeats Sandstone at the Great Unconformity about 4,000 feet below the south rim. Others would include the tilted layers of Dox Sandstone, Shinumu Quartzite, Hakatai Shale, and Bass Limestone in the Flood sediments. Some would even include the metamorphosed Vishnu Schist and Zoroaster Granite as Flood layers. Morris (1976) indicates that the entire continental Tertiary Period was probably produced by the events of the Flood. If creationists cannot agree on the location of the boundaries between major events on the continents where there are numerous exposures to study, how much less likely is agreement on boundaries in sediments miles under the ocean?

For the purpose of this first study, the partition between the Flood and post-Flood events will be assumed to be at the Cretaceous/Tertiary boundary. This is one of the most recognizable boundaries in the geologic column. It is the boundary between two of the major eras—the Mesozoic and the Cenozoic. It has been identified by creationists and non-creationists alike as the location of major changes in geologic history. In fact, some evolutionists are now suggesting worldwide catastrophic events at the Cretaceous/Tertiary boundary—namely, the impact of asteroids on the earth, a worldwide dust cloud, global winter, and the destruction of the dinosaurs and many major life forms. Many of these scenarios fit well with the devastation suggested by creationists in the global Flood of Genesis.

In addition to this easily-recognizable boundary and the catastrophism associated with it, the temperatures inferred by the ^{18}O record show a decline to the present from a maximum during the Cretaceous Period. If the oceans were heated by events of the Flood, the Cretaceous Period would logically be included in the Flood. Several warm events occurred following the Cretaceous but these were of smaller magnitude, lending support to the idea of the Tertiary coming after the year of the Flood. Use of temperature estimates from δπωO of foraminifera should always be used with caution. Some of the data sources used in this study only reported a single value at intervals of 140 centimeters. The most precise data were at five centimeter intervals, but variances were not provided.

DSDP extracted cores from 624 sites on the ocean floors of the globe. Cores from most of these sites showed only recent sediments from the Tertiary and Quaternary periods. Of the 624 total sites only 186 contained sediments from the Cretaceous period or earlier. This means that the ocean floor is relatively young compared to the continents. The mean thickness of the sediments above the Cretaceous/Tertiary boundary (as identified by DSDP based on fossils, paleo-magnetics stratigraphy, etc.) for all 186 sites was 322 meters, with a standard deviation of 273 meters. Figure 1 shows a histogram of sediment depth for the 186 sites. The mean thickness of the sediments reported below the Cretaceous/Tertiary boundary was about 400 meters in the Atlantic Ocean and 100 meters in the Pacific Ocean.

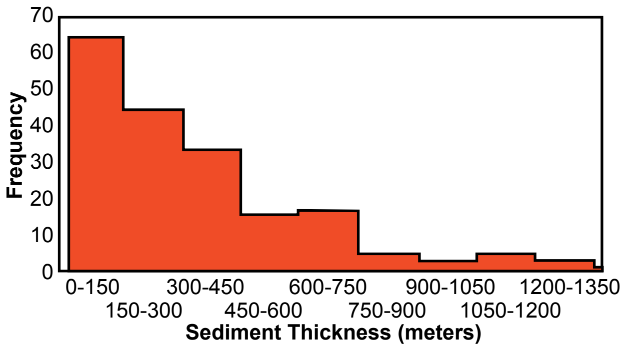

Figure 1. Frequency histogram of sediment thickness above the Cretaceous/Tertiary boundary for 186 cores from the DSDP.

A Young-Earth Model

The conventional age model used to calculate the age of sediment as a function of depth assumes that the accumulation rate of sediment was essentially constant over millions of years at today's rate of about 2×10^{-5} meters/year. If, in fact, the accumulation rate was much greater following the Flood and decreased exponentially until today, then the period of time back to the formation of a given layer can be found from the following sediment accumulation model.

Let the sediment accumulation rate be an exponentially decreasing function of time since the Flood:

$$\frac{dy}{dt} = Ae^{-\frac{t}{\tau}} \tag{1}$$

where y represents the height of a sediment layer above a reference point (in this case the Cretaceous/ Tertiary boundary), A is a constant to be determined from the boundary conditions, τ the relaxation time, and t is the time after the Flood when a layer of sediment was laid down. This equation can be integrated to give the height y directly:

$$y = A\tau e^{-\frac{t}{\tau}} + C \tag{2}$$

where C represents a constant of integration to be determined from the boundary conditions. For the first boundary condition, $y=0$ at $t=0$. It is assumed in this model that initially no sediment had yet begun to accumulate, so:

$$y = 0 = -A\tau + C \tag{3}$$

Solving for C and substituting into Equation 2:

$$y = A\tau\left[1 - e^{-\frac{t}{\tau}}\right] \tag{4}$$

For the second boundary condition, $y=H$ at $t=t_F$, where H represents the total depth of the sediment above the Cretaceous/Tertiary boundary and t_F is the time in years since the Flood. For this condition:

$$y(t = t_F) = H = A\tau\left[1 - e^{-\frac{t_F}{\tau}}\right] \tag{5}$$

Solving for A:

$$A = \frac{H}{\tau\left[1 - e^{-\frac{t_F}{\tau}}\right]} \tag{6}$$

Substituting back into Equation 4

$$y = \frac{H\left[e^{\frac{t}{\tau}} - 1\right]}{\left[e^{\frac{t}{\tau}} - \frac{e^{-\frac{t_F}{\tau}}}{e^{-\frac{t}{\tau}}}\right]} \tag{7}$$

A more useful relationship may be found by inverting this equation to find t as a function of y, H. and T.

$$t = -\tau \ln\left[1 - \frac{y}{H}\left(1 - e^{-\frac{t_F}{\tau}}\right)\right] \tag{8}$$

This relationship is typically called an age model and is used to find the age of a layer based on its vertical position. At this point, it is not specific to any particular worldview and can be applied to any chronology by substituting any time frame t_F, between the Cretaceous/Tertiary boundary and today. When applying Equation 8 to a specific site, the value of H for that site should be used, not the average sediment thickness discussed earlier.

If the chronology of the biblical events according to Ussher (1786) is assumed to be true approximately 4,500 years have transpired since the Flood (t_F=4500). Using this time interval, the average observed depth of sea-floor sediment above the Cretaceous/Tertiary boundary (322 meters), and the measured accumulation rate of sediment today (2×10^{-5}cm/year), the relaxation time, τ, may be determined from Equations 1 and 5.

Substituting the time interval since the Flood and today's sediment accumulation rate into Equation 1:

$$\frac{dy}{dt}(t = 4500) = Ae^{-\frac{4500}{\tau}} = 2\times10^{-5}\,\mathrm{m/yr} \tag{9}$$

The initial sedimentation rate, A, in terms of the relaxation time τ, may he found:

$$A = 2\times10^{-5}\,\mathrm{m/yr}\; e^{\frac{4500}{\tau}} \tag{10}$$

Substituting A into Equation 5:

$$H = 2\times10^{-5}\,\mathrm{m/yr}\; \tau\left[e^{\frac{4500}{\tau}} - 1\right] \tag{11}$$

Rewriting in order to facilitate solving for:

$$\ln\left[1 + \frac{H}{2\times10^{-5}\tau}\right] = \frac{4500}{\tau} \tag{12}$$

This is a transcendental equation in τ. The solution for τ can be found using iterative methods or by finding the point at which the two sides of the equation are satisfied jointly. The second method was used here by plotting the left and right sides of Equation 12 simultaneously and solving for τ using the average value of H. The solution to this transcendental equation gives a value for τ of 373 years. Substituting τ=373 years and t_F=4500 years into Equation 8 results in the following young-earth age model derived from young-earth boundary conditions:

$$t = -\left[373 \text{ years}\right] \ln\left[1 - \frac{y}{H}\left(1 - e^{-\frac{4500 \text{ years}}{373 \text{ years}}}\right)\right] \quad (13)$$

This age model is displayed in Figure 2. The height of sea-floor sediment above the Cretaceous/Tertiary boundary, y, is shown on the vertical axis and time since the Flood, t, on the horizontal axis. The age model is shown for several total sediment depths, H. Note, that each curve asymptotically approaches the value of H as time approaches 4500 years after the Flood. In general, it can be seen from equation (7) that y=0 when t=0 and y=H when t=t_F.

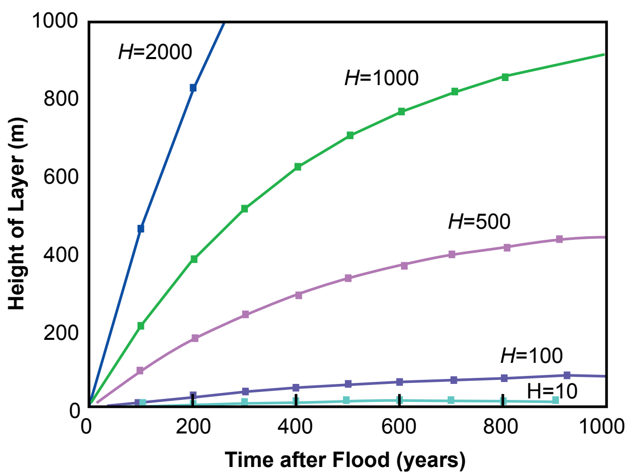

Figure 2. Age of sediment layer from the young-earth age model vs height above the Cretaceous/Tertiary boundary and the total sediment thickness, H, in meters.

Application of a Young-Earth Age Model

The age model developed here can now be applied to data used by Kennett et al. (1977) to estimate ocean temperatures from the Cretaceous to the present. The analytical procedures and interpretations are contained in Shackleton & Kennett (1975). For this analysis the total sediment thickness H above the Cretaceous/Tertiary boundary was found to be 760 meters. Figure 3 shows the results of applying the new young-earth age model to these same data.

A significantly different interpretation of the data from that of Kennett et al. (1977) results. First, the period over which the data occur is assumed to be about 2000 years, rather than 65 million years.

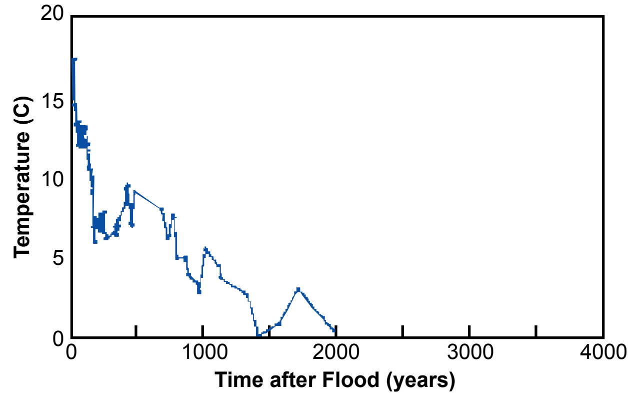

Figure 3. Polar ocean bottom temperature vs time after the Flood. Data are from Kennett et al. (1977) composited from DSDP sites 277, 279, 281.

Second the temperature initially decreases rapidly, followed by a slower decrease. The decrease shown by Kennett et al. (1977) is basically linear with a few short-period departures implying a gradual cooling over a long period of time. The trend shown in Figure 3 is typical of rapid cooling driven by a large temperature gradient. If the oceans were initially warm at the end of the Flood and were cooled to a new equilibrium temperature by radiation to space in the polar regions, this would be the type of cooling curve one would expect. The relaxation time appears to be about 1000.

This curve was derived from benthic foraminifera in the South Pacific at high latitudes, so polar ocean bottom waters show a dramatic cooling of about 20°C. Similar analyses of polar surface waters using planktic foraminifera show a similar cooling trend of about 20°C but averages that are slightly warmer. Equatorial surface waters show only a minor cooling of 5°C or so while equatorial bottom temperatures show a similar cooling trend as polar waters of about 20°C. The initial temperature for each of these cases was estimated to be about 20°C.

These results are interpreted as surface cooling of polar waters followed by sinking and movement toward the equator along the ocean floor. A general oceanic circulation is established where warm equatorial water is transported poleward at the surface and cold polar water is transported toward the equator at the ocean floor. Horizontal gyres within the separate ocean basins are superimposed on these latitudinal motions by the Coriolis force.

In the polar regions one would expect surface cooling to decrease the temperatures at the ocean floor because the cooler water aloft would sink and displace the warmer water below. This interchange would result in vigorous vertical mixing and cooling of bottom waters. During this strong cooling period one would predict outstanding conditions for nutrient supply and formation of biogenous sediments in the polar regions. In the tropics the ocean would have become more stratified with time because of the advection of cold bottom water under the warmer surface water. Except for specific regions of upwelling along the continents and near the equatorial counter-currents, vertical transport of nutrients and, therefore, the formation of biogenous sediments, would have been more restricted.

The data resolution in Figure 3 is very coarse. Near the top of the sediments sampling occurs at close intervals for the young-earth model because the sedimentation rate is decreasing exponentially. Fortunately, many cores have been extracted in recent years and sampled for $\delta^{18}C$ at very high resolution. This allows time to be resolved to short intervals near the top of the core. It is desirable that data be displayed over equal time intervals to avoid potential aliasing problems, however, this was not attempted in this study. Resampling would be required to avoid this problem which may even require additional chemical analyses.

Figure 4 shows the results of applying the new young-earth age model to a high-resolution core extracted from site RC11-120 in the sub-Antarctic Pacific at about 45° S latitude. Note that a consistent warming trend of about 5°C has occurred in the recent past preceded by rapid fluctuations at various timescales. Rapid warming followed by a slow cooling trend occurred between 1500 and 2500 years after the Flood.

The "Ice Age" in the young-earth chronology (Vardiman, 1993, 1994a, 1994b) would have ended about 2000 years ago. This event has been identified in the literature as the most recent "Ice Age" followed by rapid deglaciation. Note that the period of this event is on the order of 700 years for the young-earth model instead of the conventional 100,000 years.

If the "Ice Age" ended about 2000 years ago as suggested above, there should be evidences for recent dramatic changes in climate. Historical and

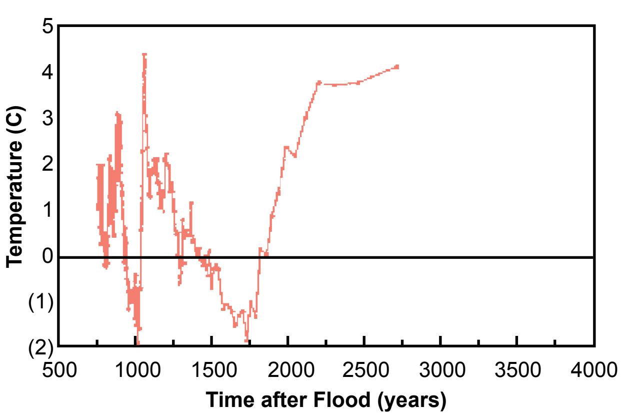

Figure 4. Polar ocean bottom temperature vs time after the Flood. Data are from core RC11-120 used in the CLIMAP project.

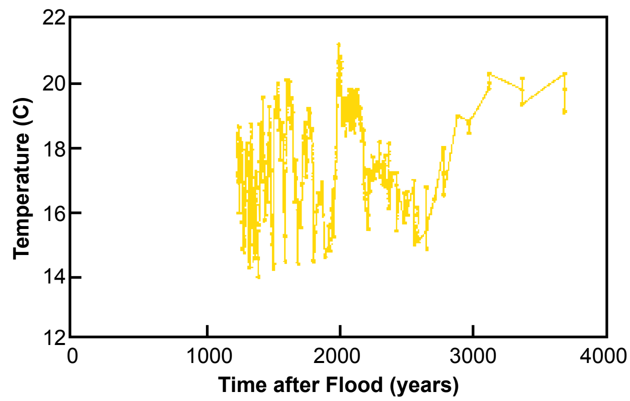

Figure 5. Equatorial Pacific Ocean surface temperature vs time after the Flood. Data are from core V28-238 used in the CLIMAP project.

archeological records between 0 and 2000 B.C. should reveal changes in ice cover on mountains and in polar regions changes in sea level, and expanding deserts. Most conventional reports place the end of the "Ice Age" between 11,000 and 20,000 B.C. With the exception of a report by Hapgood (1966) which presents data on advanced civilizations during the "Ice Age," the author is unaware of evidences for such events between the time of Christ and Abraham. The chronology earlier than about 1000 B.C. is based heavily on carbon dating techniques which are suspect if the Genesis Flood occurred only slightly earlier. The search for historical and archeological evidence for a recent "Ice Age" should be given high priority.

The young-earth age model has also been applied to a second high-resolution core taken from site V28-238 in the Pacific near the equator. The results, shown in Figure 5, also show a 5°C warming trend in the recent past preceded by similar oscillations in temperature. The period of the feature in this core associated with the most recent "Ice Age" is also about 700 years, but the temperature is about 15°C warmer. Because this core was longer than the previous one we can see a longer period of temperature oscillations into the past. Notice that these oscillations have a fairly uniform period of about 100 years. This compares to a period of about 20,000 years derived from the conventional model.

Implications of a Young-Earth Age Model

It has been recognized for several years that the layering of sediments on the ocean floor has been deposited in such a manner indicating that some type of harmonic process has occurred. Analysis of $\delta^{18}O$ in fine resolution cores show periodic repetitions of cold and warm periods. A statistical correlation between the temperature oscillations and the periods of the three orbital parameters of the earth/sun system has led to stronger support for the astronomical theory.

CLIMAP and SPECMAP were two projects designed to strengthen this relationship.

A frequency analysis of many cores with the traditional age model found that peaks in the frequency spectra occurred at periods of approximately 20,000 40,000, and 100,000 years. Because these periods were similar to those of the orbital parameters, it has been assumed that the driving mechanism for the temperature fluctuations derived from sea-floor sediments is the change in radiational warming of the earth as the earth/sun distance and orientation change. These concepts have become known as the astronomical theory a revision of a theory proposed by Milankovitch (1930, 1941).

However, several difficulties have yet to be resolved with this theory. First, the magnitude of the change in radiational heating calculated from the orbital parameters does not seem to be large enough to explain the observed cooling and heating. Secondary feedback mechanisms have been proposed to amplify the orbital effects. However, it has been found that many of the hypothetical feedback mechanisms are of the wrong sign at certain phases of the orbital cycles.

A major result of this need for feedback mechanisms has been the development of a perspective that the earth's climate systems are extremely sensitive to minor disturbances. A relatively minor perturbation would initiate a non-linear response which could lead to another "Ice Age" or "greenhouse." Because of the fear of the consequences such a small perturbation might cause, radical environmental policies on the release of smoke, chemicals, and other pollutants and the cutting of trees have been imposed by some countries. If the basis for the astronomical theory is wrong, many of the more radical environmental efforts may be unjustified.

A second difficulty with the astronomical theory is the relative effect of the orbital parameters. The orbital parameter which has a period of about 100,000 years produces the weakest change in radiational heating. If the "Ice Ages" are caused by radiational changes, the orbital parameter causing them should be the largest of the three. Yet, the orbital parameter with the 100,000 year period is the smallest of the three.

If the young-earth age model proposed by this work is valid, the conventional correlation between sea-floor sediments and the orbital parameters is completely false. The periods illustrated in Figures 4 and 5 are on the order of 100 years and 700 years. Rather than an external forcing function like orbital parameters causing fluctuation in the earth's climate system, it is suggested that these oscillations are a manifestation of frequencies which are naturally present in the earth-atmosphere-ocean system. These natural frequencies were probably excited by the initial high-energy events of the Flood. In the young-earth model there has been only enough time for one "Ice Age" since the Flood. The initial forcing function for the "Ice Age" was the tremendous amount of heat left in the oceans by the events of the Flood. The length of the "Ice Age" would have been determined by the amount of time for the oceans to lose their heat to the atmosphere and subsequently to space.

Many other shorter-period oscillations in the earth's climate system may still be operating, however. For example, a significant oscillating climate event which has received a large amount of international research attention recently is the El Niño Southern Oscillation (ENSO) which has been documented in the equatorial Pacific (Jacobs et al., 1994). This climate event starts as a warming of surface waters in the western equatorial Pacific. It progresses eastward over a period of two to four years increasing precipitation along the equator and changing the wind patterns. When it intersects the Americas, it produces flooding and major changes in marine habitats along the west coasts of both continents. Effects further east cause wet and dry regions over large areas. This oscillation has a period of about seven years and may be just one example of many such oscillations still observable in our atmosphere/ocean system. If a young-earth model of sea-floor sediment accumulation such as that developed in this monograph can be justified, the conventional theories of multiple "Ice Ages," greenhouse warming, and millions of years of earth history required for evolutionary processes will be refuted.

Conclusions and Recommendations

An alternative, analytic, young-earth model of sea floor sediment accumulation has been developed in this treatment. Rather than a slow accumulation of sediments at a nearly constant rate of a few centimeters per millennium over millions of years, an initially rapid accumulation of sediments decreasing exponentially to today's rate over some 4500 years was assumed. Observations of $\delta^{18}O$ from sea-floor sediment cores were transformed to estimates of temperature and plotted as a function of time of deposition in accordance with this exponential model.

These plots indicate that temperature at the floor of tropical and polar oceans and the surface of polar oceans decreased rapidly, immediately following the estimated end of the Flood. This decrease was on the order of 15 °C and asymptotically cooled to today's average value of 4 °C. The major portion of the cooling occurred in about 1000 years, in agreement with Oard's (1990) estimates of cooling following the Flood. Application of this model to very detailed tropical cores found a consistent warming trend of about 5 °C over the recent past, preceded by rapid fluctuations of temperature at various time scales. The period of the longer fluctuations, typically identified with the "Ice Ages," is on the order of 700 years, rather than the conventional 100,000 years. The period of the shorter fluctuations is about 100 years, compared to the conventional 20,000 years.

The major decrease in oceanic temperature by 15 °C, following the Cretaceous Period, is suggested to be the cooling of the ocean to a lower equilibrium temperature following the Genesis Flood. The 100-year and 700-year fluctuations are suggested to be transient oscillations as the ocean/atmosphere system reached equilibrium.

Massive quantities of data available from DSDP ODP, and other sea-floor core drilling projects may be used to investigate other features of sediment accumulation from a young-earth perspective. $\delta^{18}O$ is only one of many variables available for such studies. Cores from almost 1000 sites and nearly every region of the ocean floor are available for study. It is likely that an entirely new understanding of paleoceanography could be developed from this preliminary age model.

In order to improve the young-earth model proposed here, similar analyses should be made of $\delta^{18}O$ measurements for many additional cores. The results of Douglas & Savin (1971, 1973, 1975), Savin, Douglas, & Stehli (1975), and Shackleton & Kennett (1975) should be replicated with more recent cores over a wider geographic distribution. $\delta^{18}O$ observations from the upper 50 meters of sediment would be of particular interest. Further consideration should be given to the identification of the Flood/post-Flood boundary. It may be that the Cretaceous/Tertiary boundary is too deep in the geologic column. A larger survey of sediments above the Cretaceous/Tertiary boundary may lead to smaller values for a typical thickness, reducing the model accumulation rate and revising other parameters in the young-earth model. A universal average sediment thickness should not be used to plot time versus depth at any single site.

An analysis of the productivity of biogenous sediments in the post-Flood ocean should be made and compared with the mass of sediments observed. The accumulation of hundreds of meters of sediment, on the average, and kilometers of sediment in some locations, such as the Arctic Ocean, require very high productivity following the Flood. Although the potential for high productivity has been suggested by Roth (1985), can the oceans supply enough nutrients, in some 4500 years, to explain the observed sediments?

Refinements in the young-earth model should be made to better simulate the formation of sediments. Such assumptions as the exponential decrease in accumulation, the total depth of post-Flood sediments, and the composite of biogenous and lithogenous sediments should be explored further. The model may need separate parameters for different oceans, latitudes, and sediment types, as well as sites.

A similar study should be conducted for $\delta^{18}C$. $\delta^{18}O$ was selected for this first study because of its immediate relationship to climate and the polar ice sheets. However, the burial of carbon has major implications on the mass balance of carbon in the hydrosphere biosphere, and atmosphere. It affects the formation of carbonates, the radiation balance and temperature of earth, and paleochronometers such as ^{14}C. Combinations of $\delta^{18}O$ and $\delta^{13}C$ may be useful for estimating productivity and sediment accumulation rates.

The result of this effort was to initiate the development of an analytical model of sea-floor sediment accumulation. The model uses the measured sediment accumulation rate of today, the observed sediment depth on the ocean floor, and a literal biblical time frame as boundary conditions. An exponentially-decreasing accumulation function was assumed. All of the questions have not been answered. In fact, this monograph may raise more questions than it answers. Other researchers are encouraged to work on portions of this problem and to keep me informed.

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