RESONANCE AND SEDIMENTARY LAYERING
IN THE CONTEXT OF A GLOBAL FLOOD

M.E. Clark and H.D. Voss
Genesis Research Laboratory
2020 Zuppke Drive
Urbana, IL 61801

ABSTRACT

Much of the layering in the sedimentary column demands a cyclic mechanism for its development. Newton's gravitational attraction principle as manifested in the tides provides such a mechanism. The Resonance phenomenon, produced by tides and other excitation sources, are invoked to provide the global ocean tides with the ability to transport and deposit the required amount of sediment. Computer simulations are used to develop an understanding of the events.

INTRODUCTION

Sedimentary structures cover the earth in profusion. While some of these structures are due to deposition by the wind, the vast majority have been deposited by water. Many of these structures are characterized by their enormous lateral extent, reaching over vast areas of the earth's surface, requiring the label "persistent facies". Another distinct characteristic is the parallelism (if not the horizontality) of the sedimentary layers. Logic requires that the watery depositional medium was as extensive as the facies and that it was an active agent in the sedimentary layering process. The thought vector points to a global flood and to a flood geology. Such was the prevalent view prior to the Darwin revolution and it was held by the vast majority of the scientists of the day, some of whom were responsible for the invention of the so-called geologic column. With gradualism a firm requirement in the evolutionary process, it was necessary to have a concomitant uniformitarian interpretation of the geologic record. But this interpretation, that the sedimentary structures were developed slowly with ancient sea-floor subsidence equalling the "gentle rain" of sediment from above, proved to be no more satisfactory than was Darwin's interpretation in the biological sphere. Accordingly, non-creationists are presently espousing saltational advances in biology and catastrophic mechanisms in geology. The latter explanations, however, do not involve the one vehicle which lends credence to the catastrophic viewpoint, the global flood. To attempt to explain the development of the layered column of sedimentary structures without a body of water as extensive as the persistent facies is illogical. Of necessity, a body of water that large would undoubtedly extend by hydromechanic principles to the ends of the earth. Thus, the global ocean had to be a reality in the history of the earth. The sedimentary layers on top of all the principle mountain ranges today witness to the conclusion as well.

The need exists among young-earth creationists to explain the events associated with the rapid formation of the sedimentary column on top of the basement rocks of the original creation and above the sedimentary layers of the original runoff associated with the uplifts of Genesis 1. Once the concept of a global ocean is accepted, it is possible to develop rational fluid-- mechanic mechanisms capable of producing sequences of sedimentary layers. The amount of sedimentary material is huge but an ample source of mineral material can be postulated as coming from the opening of "the fountains of the great deep"(Gen.7), if these events can be interpreted as tectonic activity similar to that occurring today with the eruption of volcanoes. If one Mt.St.Helens can scatter millions of tons of debris over the northwest United States, what would be the case of a thousand such occurrences in a few months of time? The lush antediluvian vegetative and animal environments would have provided sufficient material for the coal and oil deposits found in the column. What remains to be explained are the mechanisms which can take these materials and lay them down in horizontal (or nearly-horizontal parallel) layers of great lateral extent in a relatively short period of time, in a minuscule amount of geologic time. Many evolutionary geologists are now ready to invoke catastrophism as the prominent mechanism for generating sedimentary structures, however, they want nothing to do with the young-earth concepts of limiting this generation to one catastrophe with its limited time-span of one year. So there is still a dichotomy between evolutionary and creationary explanations of the geologic record even though both use the catastrophic approach.

The thrust of this paper is to offer a modern interpretation of a mechanism of long standing, dating back possibly as far as Sir Isaac Newton, for the development of a major part of the whole sequence of conformable layers. Newton is, at the least, responsible for the development

of the basic principle involved, that is his law of gravitational attraction. Whether the impetus for this development was inspired by the Scriptural account of Noah's flood has not been confirmed in the literature. Since he was a firm believer in the exactitude of the Bible, his work on the tides could have been fostered by his Biblical studies. This gravitational attraction principle as manifested in the lunar and solar tides is the one fluid-mechanic mechanism possessing sufficient power and world-wide scope that could accomplish the buildup of the sedimentary column in the allotted time. Present-day tides have amplitudes too small to produce velocity fields sufficiently large so as to be able to move the required amount of sediments at the bottom boundaries of a global ocean. However, present-day tides move in oceans of limited extent where the tidal mechanism is frequently interrupted in its development by land masses. Hence, the build-up of amplitude of these tidal waves is hindered. During the flood year, when the waters completely covered the globe, these hinderences would have vanished and then the repetitive cyclic activity of the tides would have had the possibility of moving towards resonance with the accompanying build-up of tidal amplitude and the accompanying ability of the tidal waves to move the sediment at the bottom of the ocean. Since no incontrovertible time marks are stamped on the geologic record and since the biblical record speaks directly in terms of days, we feel justified in seeking out a method that would rapidly manufacture the sedimentary column.

TIME AND SEDIMENTARY LAYERING

Since the evolutionary and creationary catastrophic explanations of the build-up of the geologic column differ primarily on the matter of the time necessary to do the building, the following points of discussion deal with the characteristics of the column that require or demand rapid build-up.

1. The fact that the layers are conformable and follow in unbroken sequence one on top of the other requires a rapid (within hours) deposition rate. Conformable means that the layer above lies directly on top of the layer below with only a fine line of demarcation between. Because of the water deposition, undisturbed layers would be horizontal; if tilted, at least they would be parallel. If the lower layer was not quickly covered and weeks, months, or years passed instead, the top surface would have been cut by erosional features, especially since the watery medium which laid the material down would still be present to cut it up. With long periods between layers, root systems of plants and trees would also have been developed. Since the demarcation line is fine, it means that none of these events occurred because there was not enough time for them to eventuate.

2. Since there are no world-wide unconformities, each of the conformable layers can be traced around the intruding features. Since each of the conformable layers was produced rapidly, the sequence of layers must have been also.

3. The fact that so many fossils are found in the layers requires their rapid deposition. The fossilization process requires rapid burial, otherwise, the animal remains will decay, will be taken by predators, or will be mechanically destroyed by the elements. The fossilized tracks of animals are all the more susceptible to destruction unless covered almost immediately by a subsequent layer.

4. The presence of cyclothems in many parts of the stratigraphic record, where coal seams are seen as just another layer in the overall sequence of rock layers, indicates that coal formation was a rapid event as well. This event came about when the lush vegetative material from the antediluvial world (uprooted, ground into pulp by the water agitation, and left floating on top of the flood waters) became waterlogged or heavy due to accumulation of debris from the atmosphere and sank periodically to the ocean bottom there to form the coal layer. The great lateral extent of these coal layers also calls for a global ocean. The fact that there are no root systems growing into the layers below the coal seam argues against a grown-in-place theory and for a come-from-elsewhere theory.

5. The fact that there are such huge oil deposits throughout the world, the ingredients of which had to come from living sea and land animals and plants, necessitates that these deposits are the sites of vast graveyards of these living things. The remains have been transformed into their present form by heat and pressure. Only catastrophic motion within a global ocean could have moved all this mass into such extensive accumulations.

6. The mass graveyards of animal remains which have not been so transformed to oil also agree well with the rapid layering scenario. Animals of different types who are normal enemies do not congregate together for their last rites. They must have been caught up in flood waters and transported to the place of burial, there to be covered rapidly for fossilization and preservation by the subsequent layers of sediment.

7. Polystrate fossils argue persuasively for a rapid layering rate. How could a tree remain intact and vertical for such extended periods of time as to have 10 to 12 distinct layers of the column built up around it if each layer took centuries to make? Contrariwise, the tidal layering mechanism could place those 10 to 12 layers in less than a week.

8. The fact that no meteorites have ever been found buried in the geologic column but rather are concentrated near the earth's surface is further evidence that each layer was not on the surface very long before being covered over and that the whole column was placed within a short time span. Meteoritic activity was probably greater in the past when the universe was younger and so more not less meteor deposits should be found in the column if it is geologically old.

WAVE PHENOMENA

Two types of wave phenomena can be associated with the formation of the sedimentary column. The tsunami is a wave motion associated in some way with sudden shifts in crustal position, either the subterranean sub-aquatic earthquake or the slippage of a great earth mass down a slope into a large body of water. Early during the flood year, when the "fountains of the great deep" were building up the water depths on the earth and before the gravitational attraction principle could have significantly affected the waters, large tsunami waves could have moved much sediment from place to place. Such depositions would, however, have lacked order and the layers thus deposited would have been haphazard and without pattern. Once anything near a global ocean was present, the tsunami would have lost its major role. It could have persisted in conjunction with the tidal wave mechanism for a while but would have been relegated to a minor role as the waters gained in depth or as the eruptions of the fountains ceased.

The dominant mechanism in the rapid formation of the sedimentary column must have been the gravitational attraction phenomenon created by the presence of the moon (and to a lesser degree the sun). A global ocean in the presence of such a large earth satellite would have had to react to it with the formation of semi-diurnal bulges of water which touched every point of the earth's surface. These bulges would have had wavelengths equal to half the earth's circumference. The parameters yet to be determined are their amplitudes. As mentioned previously, present day tides range from 2 to 5 meters in amplitude at most places on the earth. Where they are larger than this, the phenomenon of resonance is the cause of the increase. The Bay of Fundy in Nova Scotia has tidal amplitudes of 17 meters but it has an appropriate bottom slope and geometric planform and length so that the reflections of the tidal waves from the end of the Bay reinforce the incident waves coming in at the mouth in just the right way so that resonant buildup of amplitude occurs.

There is little doubt that much larger tides would occur today if the tidal action was not interrupted by the large continental land masses. The amplitude buildup that could occur without such interruptions would be of a different kind than that which occurs in the Bay of Fundy. There the wave reflection phenomenon is dominant. Reflected waves, carrying their own sediment load, could have played a secondary role in the buildup of the column. Reflection sites could be attributable to uneven terrain on the ocean bottom or land masses not yet covered by the flood waters or land masses uncovered as the flood waned. Resonance on a global ocean of uniform depth would occur when the forced wave speed equals the free wave speed. The forced wave speed, due to the gravitational attraction of the moon, is known since the period of the moon is known to be 24 hours and 50 minutes. For a semi-diurnal wave length of half the earth's circumference at the equator (20,000 km), the forced wave speed is 1614 km/hr (1003 mph). The free wave speed is the speed of travel of a disturbance imposed on the ocean, say by some giant drumstick hitting the ocean or by a sub-aquatic earthquake which causes a surface disturbance to emanate therefrom. Since tidal waves can be classified as shallow water waves because of their large wavelength, the speed of a disturbance is given by the square root of gH where H is the ocean depth. The depth to obtain the 1614 km/hr value would be 20 km. For a global ocean of this depth, the resonance condition would be met at the equator. Since the mean depth of today's oceans is about 3.14 km, the 20 km depth would represent a huge increase in the amount of water needed to fill the global ocean. However, if a latitude of 60 degrees rather than the equator is considered, the forced wave speed is halved since the circumference at 60 degrees is halved. The depth to obtain a free wave speed of 807 km/hr is only 5.12 km, a much more reasonable answer.

The resonant condition, with its extremely large amplitudes, can be thought to develop as follows: The moon attracts the waters of the global ocean pulling them up to form a tidal bulge. Due to its rotation on its own axis, the earth moves underneath the moon. The bulge then takes on the characteristics of a wave moving over the ocean as the moon seemingly moves over the earth. At each instant, the moon is essentially creating a new wave much the same way as the great drumstick would create a wave. After each new wave is created, it moves over the ocean at a speed equal to the free wave speed. If the ocean depth is 20 km, the free and forced waves travel at the same speed at the equator and each new wave created by the moon would travel at

that speed as well. The accumulation of these waves all moving at the same speed would be manifested by a buildup of amplitude to enormous heights.

CANAL THEORY AND COMPUTER SIMULATION

The availability of present-day digital computers allows many large-scale and small-scale real-world events to be simulated. An event as large as a global flood is no exception. As long as the governing equations, the boundary conditions, and the forcing functions are known and can be programmed, information regarding the event can be generated. The amount and applicability of the information is determined by the complexity built in to the simulation. The most appropriate model of a global ocean would be constructed using spherical coordinates and governing equations. Many such models have been constructed for the present-day ocean topographies. No references have been found that pertain to a global ocean using the spherical constructs. There are, however, many references to simpler modes of analysis, primarily canal theory. This theory postulates a two-dimensional analysis with a canal running circumferentially at the equator (or any other latitude) with the moon travelling directly overhead. The semidiurnal tide is expected to be the major mode of oscillation on this global canal since it is forced by the earth's rotation rate. The magnitude of the amplitude of the wave response to these forces is very much dependent on whether the frequency of the forcing function is near the natural frequency of the system. Observations (1,2) suggest that the earth's oceans have natural modes with frequencies about 12 hours.

To investigate some aspects of the global ocean problem, it is useful to consider the semidiurnal tide using a simple zonal canal, shown without curvature in Figure 1, that extends about the circumference of the earth (3). The rotational dynamics are considered to be of second order for such a two-dimensional canal and the governing equations are considerably simpler. Cancellation of the rotational ($\omega \times V$) and viscous ($\nu \nabla^2 V$) terms in the generalized momentum equation reduces it to an Euler equation which can be written as:

$$\frac{\partial u}{\partial t} = -g \frac{\partial (S - S_e)}{\partial x} \tag{1}$$

where S_e is the surface height of the equilibrium tide (the tide that the global ocean would adopt if there were no dynamic effects due to the rotation of the earth). This equation shows that the time-varying currents in the global ocean are independent of depth. Equation 1 can be used to simplify the generalized continuity equation so that it can be integrated with respect to depth. Using the boundary conditions at the bottom (w=0 at z=-H) and at the surface (w= $\partial S/\partial t$ at z=S), the continuity equation becomes:

$$\frac{\partial S}{\partial t} + H \frac{\partial u}{\partial t} = 0 \tag{2}$$

In a zonal canal, the equilibrium tide may be approximated(3) by:

$$S_e = A \sin(2kx - 2\omega_1 t) \tag{3}$$

where $2\omega_1$ is the frequency of the semidiurnal tide ($2\pi/\omega_1$ = a lunar day of 24 hours and 50 minutes), and k = $2\pi/\omega_1$ where l is the semi-circumference of the earth at the latitude of the canal. Differentiating Equation 3 with respect to t and combining the result with Equation 2 yields an equation for the dependent variable S as follows:

$$\frac{\partial^2 S}{\partial t^2} = -H \frac{\partial^2 u}{\partial x \partial t} = gH \frac{\partial^2 (S - S_e)}{\partial x^2} \tag{4}$$

This result is in the form of the wave equation with wave speed c equal to the square root of gH. Using a sinusoidal response as a solution to the wave equation, the result is of the form:

$$S = S_0 \sin(2kx - 2\omega_1 t) \qquad (5)$$

Substitution of Equations 4, 6, and 7 into Equation 5 gives an expression for S_0, the wave amplitude, as follows:

$$S_0 = A/(1 - (\omega_1/ck)^2) \qquad (6)$$

Near resonance, the long-wave speed $c=(gH)^{1/2}$ approaches the equilibrium tide speed ω_1/k, and the amplitude S_0 approaches the resonant value of infinity. Calculations of free modes in the present-day oceans have shown frequencies near the semidiurnal frequency (4). The viscous term, eliminated from the momentum equation, acts to limit the resonant amplitude of infinity and to produce large but reasonable values. These terms which have been eliminated from the foregoing analysis can be reinstated in the governing equations when numerical methods are used in the solution of the equations.

In a previous paper (5) concerned primarily with establishing the validity of a canal theory computer code developed from a SOLASURF code (6), many model and a few prototype situations were computed. The equilibrium tide at the equator was determined as a function of viscosity. Since those results are pertinent to the present discussion, they are presented in Figure 2. All calculations were started at a canal depth of 20 km, the depth at which resonance was expected to occur with the lunar force field. As is seen in the figure, for inviscid motion ($\nu = 0$) the tidal amplitude oscillated freely at what one would expect to be the natural frequency of the system. The period of this oscillation is seen to be about 48,000 sec (13.33 hr), somewhat greater than the 12.42 hr corresponding to the lunar semidiurnal tide. Since there is no dissipation, this oscillation would continue indefinitely. When increasing amounts of viscosity were added to the fluid, the oscillation amplitudes decreased. For $\nu = 0.0004$ and 0.004 km²/sec, the motion appeared as an underdamped approach to the equilibrium tide height of 20.047 km. For $\nu = 0.04$ km²/sec, the free surface did not oscillate but made an overdamped approach to the equilibrium tide height.

The canal theory code was used to investigate the variation of tidal height with the angular velocity associated with the rotation of the earth on its own axis. In the left most frame of Figure 3, the equilibrium tidal height at the equator is compared with the solution for an angular velocity of 0.00007 rad/sec (the value corresponding to the lunar day). Both calculations were made with the same amount of damping, $\nu = 0.004$ km²/sec. Whereas the equilibrium tidal height peaks at about 20.075 km, the tide on the rotating earth peaks above a value of 20.10 km. The curve shows a decreasing slope at the end of the calculational period so it seems evident that this calculation (if continued) will not lead to an excessively large tidal amplitude (although an amplitude of 100 meters is not small). It is possible that, with more calculational effort, this curve could experience some oscillations and each successive oscillation could range higher in amplitude. These calculations were quite CPU intensive so they were terminated at 44,000 sec. Another treatment of these same data is presented in the bottom frame of Figure 4. Here, the temporal development of the tidal free surface over the complete equatorial circumference is shown. Two rates of advance of the tidal bulge are evident with the second (and greater) advance rate starting after the dwell between 20 and 25,000 sec seen in Figure 3. The cause of the change in advance rate is not obvious but could be due to some complex interaction between the components of the lunar gravity forces(5).

Returning to the right most frame in Figure 3, the corresponding 60 deg latitude calculation is shown. As indicated previously, the depth associated with resonance (on the basis of equality of the two wave speeds) was calculated to be 5.12 km. The curve represents the computer results for the earth angular velocity of 0.00007 rad/sec and a viscosity of 0.004 km²/sec. The initial peak occurs at 5.132 km after which the tidal height demises, rises again slightly, and seemingly settles at a depth of 5.129 km where the calculations were terminated at 68,000 sec. The temporal development of the free surface is also depicted in the upper frame of Figure 4. Again, two rates of advance of the tidal bulge are seen. Not much evidence of resonance at this latitude is apparent in either figure. For the equatorial canal, it was noted that the period of the natural mode of oscillation for the 20 km depth was greater than half the lunar day. There is the distinct possibility that some other depth in the neighborhood of 20 km would produce a tide height greater than 20.100 km even one that would develop excessive heights moving towards infinity as indicated by Equation 6. It would take a cut and try process to locate such an initial depth at the expense of a great amount of CPU time. Since there would undoubtedly be a gradual build-up to resonance, each trial would have to be given an extended calculational effort before deciding it was not the resonant depth. Such a process is being contemplated for future work.

Hough(7) solved Laplace's spherical tidal equations using some semi-analytical methods and calculated the ratios of the tidal height to the equilibrium tidal height for various ocean depths. He says "We see, then, that though, when the period of forced oscillation differs from that of one of the types of free oscillation by as little as a minute, the forced tide may be nearly 250 times as great as the corresponding equilibrium tide. . . . The critical depths for which the lunar tides become infinite are found to be 26,044 feet and 6,448 feet. Consequently, this phenomenon will occur if the depth of the ocean be between 29,182 and 26,044 feet or between 7,375 and 6,448 feet." Here then Hough, with spherical governing equations, was able to show resonant conditions at reasonable ocean depths. It would seem prudent to repeat Hough's calculations using present-day numerical methods. Such work is also contemplated in the future.

CONCLUSIONS

A survey of the literature showed ample evidence that tidal resonance is a phenomenon that can occur in today's oceans. When, in a global ocean, the disruptive barriers are removed, the resonance activity would be considerably greater. Accordingly, the cyclic action of the tides is put forth as a viable method for the rapid building of the sedimentary column during the year of Noah's flood. Computer simulations of the tidal event based on canal theory are capable of duplicating the buildup of the tidal amplitude. Parameter studies help to explicate this complicated event.

REFERENCES

1.   Garrett, C.J. and Greenberg, D.A., "Predicting Changes in Tidal Regimes", J.Phys. Oceanography, Vol.7, pp. 175-181, 1977.

2.   Heath, R.A., "Estimates of the Resonant Period and Q in the Semi-dirunal Tidal Band in the North Atlantic and Pacific Oceans", Deep-Sea Res. Vol.28, pp. 481-493, 1981.

3.   Gill, A.E., "Atmosphere-Ocean Dynamics", Intern. Geophys. Series, Vol.30, Academic Press, 1982.

4.   Platzman, G.W., Curtis, G.A., Hansen, K.S. and Slater, R.D. "Normal Modes of the World Ocean", J. Phys. Oceanography, Vol.11, pp. 579-603, 1981.

5.   Clark, M.E. and Voss, H.D. "Gravitational Attraction, Noah's Flood, and Sedimentary Layering", Science at the Crossroads, Onesimus Pub.MN, pp. 42-56, 1985.

6.   Hirt, C.W., Nichols, B.D. and Romero, N.C. "SOLA-A Numerical Solution Algorithm for Transient Fluid Flows", Los Alamos Sci.Lab., Rept. LA-5852, 1975.

7.   Hough, S.S. "On the Application of Harmonic Analysis to the Dynamical Theory of the Tides", Phil. Trans. Royal Soc. Vol. CXIX, pp. 139-185, 1897.
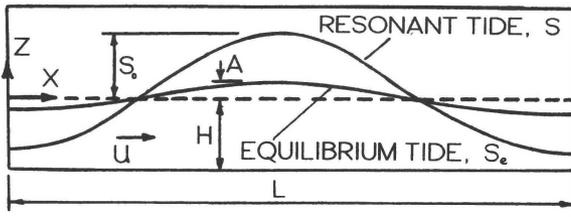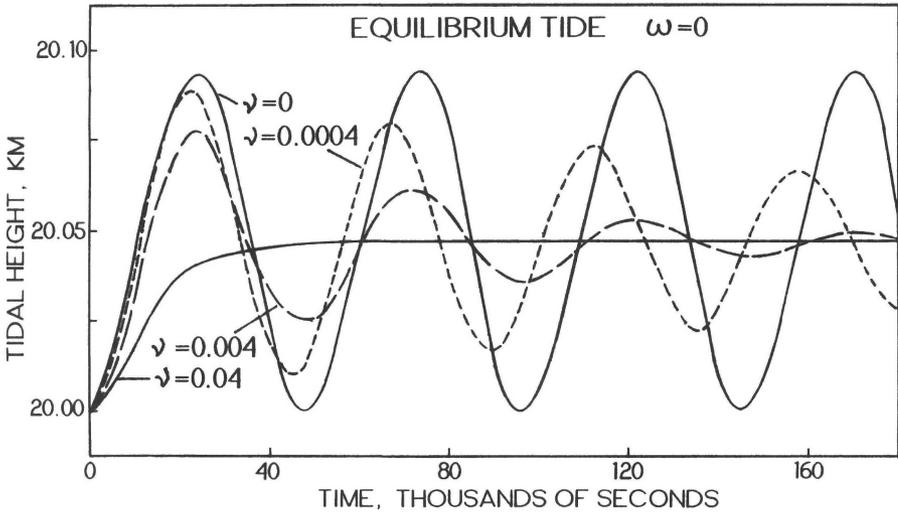
FIGURE 1 CANAL THEORY DEFINITION SKETCH

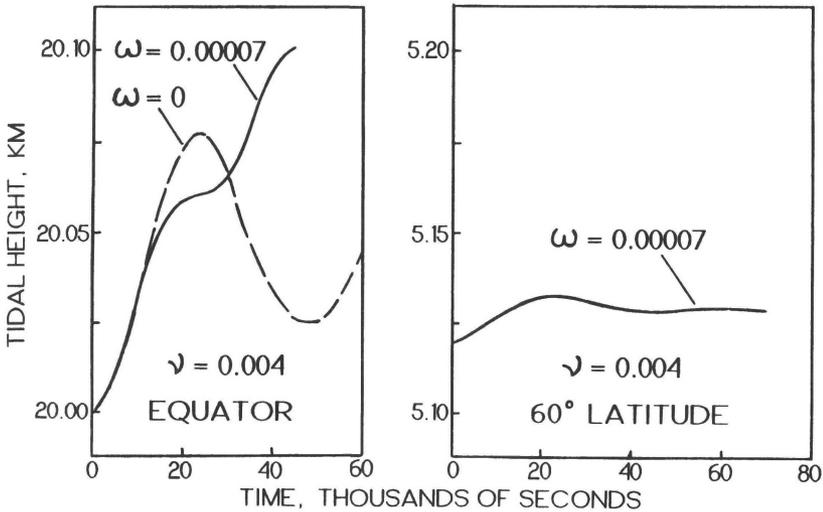

FIGURE 2 EQUILIBRIUM TIDE WITH VARIOUS AMOUNTS OF DAMPING

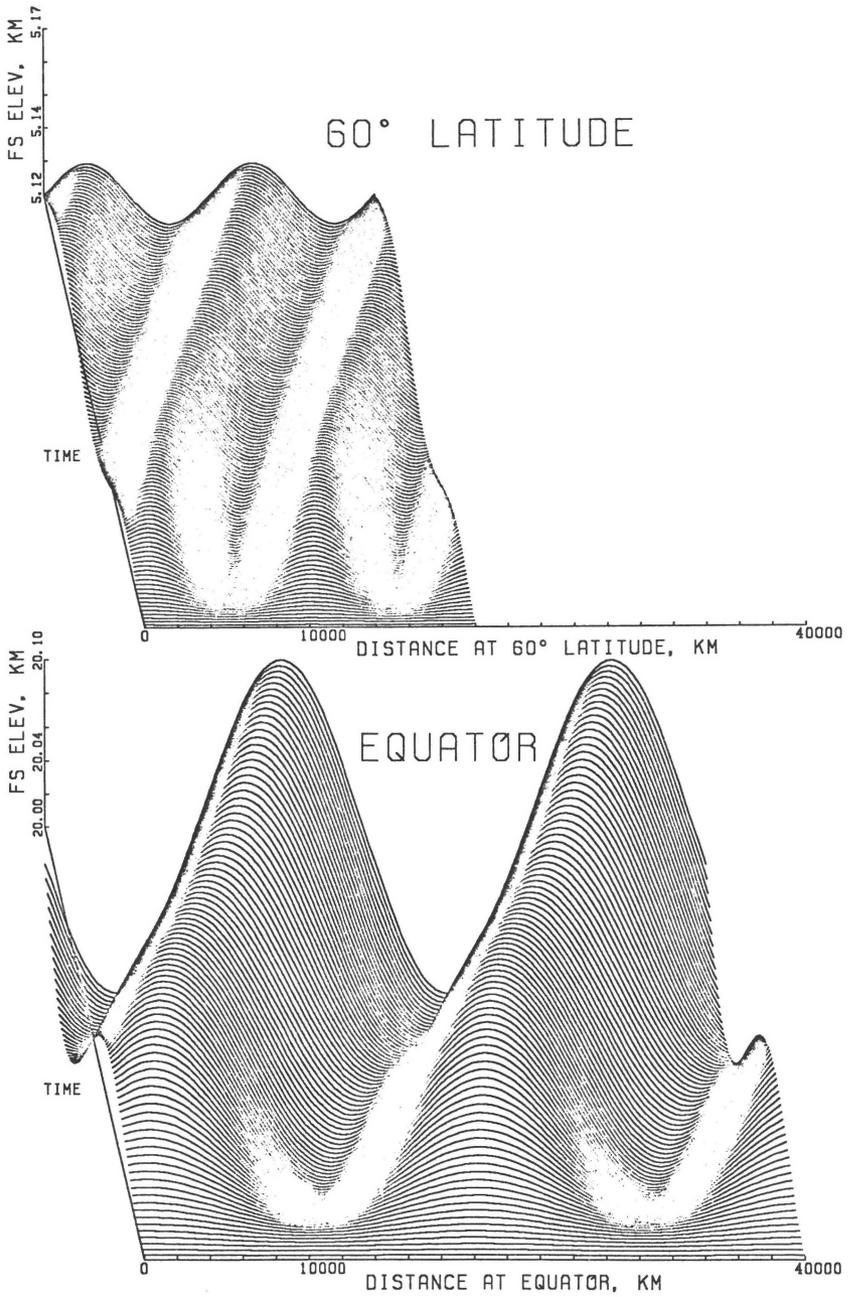FIGURE 3 TIDAL HEIGHT VARIATION WITH ANGULAR VELOCITY

FIGURE 4 TIDAL FREE SURFACE VARIATION WITH TIME

This paper exhibits a fine effort to apply theoretical modeling to geology. It may very well be that the authors have identified a primary mechanism for Deluge sedimentation.

As an observation, however, (rather than a criticism) the endeavor suffers from necessary simplification. If the earth's sedimentary deposits were of an "onion skin" nature with beds typically continental in scope, then the tidal mechanism would certainly play a dominant role.

Unfortunately, the deluge deposited things unevenly. The geologic record does not, in my opinion "demand a cyclic mechanism," as much as it does a continually recurring suite of mechanisms. Nonetheless, the need to simplify for analysis is beyond question. In this, the authors have done an admirable job!

I would favor greater weight placed on tsunamis due to the "fountains" which continued pulsating for 150 days (Gen 7:11 - 7:24 - 8:2). Such processes do produce (contrary to the author's assertion) bedded deposits. The author's simplifying assumption of a constant water depth worldwide cannot be true, (and they would not claim it to be) but does not the tidal model depend on the lack of shallow areas which would inhibit resonance?

John D. Morris, Ph.D.
San Diego, California

1. The authors need to identify geologically that which they call, "the basement rocks of the original creation". I have not been able to recognize any formations in the bottom of the geological column which could qualify.

2. The theoretical presentation of the paper is excellent. It undoubtedly points to a major depositional factor in that section of the geological column which represents the Noahic Flood in its near global or at its global stage. However the paper fails to face the question: "Where are the Noahic Flood layers in the geological record today. The paper also fails to consider the great variety found in the actual deposit series in the geological column in the field. These are far too diverse simply to represent oscillating marine disturbances of the Noahic ocean bottom. Regrettably the theory does not approach nor consider the vast scope of field evidence.

3. In turning to "...the lush antediluvian vegetative and animal environments.." for the source of coal deposits, the authors need to raise the question: "Where is the Noahic Flood and deposit of antediluvian debris recorded in the geological column?" Coal is found in several sections of the geological record, obviously recording diverse stages of Biblical history. Are all of these Noahic tidal deposits?

4. The paper largely ignores violent submarine crustal movement in the deepening of ocean basins after the Noahic Flood and in the rapid separation of the continents well after the Flood as an instrument generating high velocity, erosive, and depositional waves.

5. I propose that the great bluffs of Mesozoic beds exposed at the juncture of the Green and Yampa Rivers at Echo Park near the Colorado/Utah border as a specific location for oscillation study. I interpret these bluffs as evidence of alternating wind deposits interrupted by tidal intrusions. However, I long have "oscillated" between a tidal and a tsunami explanation of these interruptions.

6. In the discussion of page 4, a third cause of serious wave phenomena depositing major sedimentary beds, not mentioned by the authors, is horizontal plate movement. See the Franciscan Assemblage of Northern California (Bul. 183, California Division of Mines and Geology) and my comments in the Creation Research Society Quarterly, March, 1970. This assemblage of formations appears to be the violently ground, rapidly deposited deep submarine deposits ground by the continental plate overriding the eastern margin of the vast Pacific Ocean. Estimates of this deposit have run to 50,000 feet thick, hardly a minor depositional role that can be ignored. Neither can it be explained by cyclic Noahic Flood tidal erosion and deposition. It is an unrelated, catastrophic deposit from centuries later.

Bernard E. Northrup, Th.D.
Redding, California

After a useful and descriptive introduction establishing a physical model (pages 1-5), the rest of the paper appears to be essentially the computer output of a simplified mathematical model based on the physical model. Within the limits imposed by such mathematical simplification of

the worldwide convulsion of sea, air, and land which we blithely call, "The Genesis Flood", the authors' paper may well give some useful answers that match the real world after the Flood in some places. I recommend that the authors research earlier attempts at portraying the comprehensive total Flood catastrophe (i.e. mechanics, sequence of events, tectonic, thermodynamic, geologic, and hydraulic effects, etc.), done by biblical creationists, such as in, The Fountains of the Great Deep, and the Windows of Heaven, Proceedings of the 1983 National Creation Conference, Minneapolis, MN, pp. 98-104.

Robert L. Whitelaw, M.S.
Blacksburg, Virginia

CLOSURE

As shown in this paper, it is the resonance condition that can transform a weakly disturbed global ocean into a strongly pulsating ocean. The tidal force between the moon and a one kilogram mass located on the surface of the earth is only about 5E-5 Newtons (about 2.3E-5 pounds). Yet, the periodic application of this small forcing function has been shown to be capable of producing enormous periodic tidal waves. Various mechanisms may have contributed to the excitation of the global ocean. These mechanisms may have been random impulses like earthquakes, tsunamis, or "fountain of the deep" motions. Those mechanisms which were periodic, however, would have been the only ones which would have been responsible for the development of the resonance condition.

In this paper, we have suggested that tides were the important fluid dynamic force because the tidal period of about 12 hours is near the global ocean resonance period of about 12 hours. Just like in a swing, every little push increases the swing's amplitude but only if the push is in synchrony with the natural frequency of the system. This analogy is similar to tidal resonance in that the rotation of the earth-moon system would "push" the global ocean every 12 hours, building up large tidal waves (equation 6) which would have included in them the fluid dynamics to cause massive sedimentary layering.

An ocean near resonance could also be subjected to impulsive excitations. In the swing analogy, such an occurrence would be similar to creating a large swing amplitude by a single push. In such an underdamped case, the swing will oscillate many times near resonance before slowing down and coming to rest. For a global ocean, the effect of a large wavelength impulsive force would be to cause significant ringing near the ocean's natural frequency.

Because the sedimentary record, from the Cambrian to the Mesozoic, shows massive parallel sequences of layered rock, the inference is that a massive and pulsating fluid mechanism must have been responsible. In addition to the many technical references to these massive sorted facies in the geologic record, we have studied in detail much of the geology of the Illinois basin and have built experimental equipment to further model sedimentation associated with various dynamic fluid fields. It is beyond the scope of this paper, however, to discuss either geology or sedimentation. The causes and construction of the actual geologic column as it appears in various regions on the earth is a complicated problem that will require many and various techniques to obtain even some partial solutions. Computer simulations, using the basic underlying fluid-mechanical governing equations, is one of those techniques. We have attempted to underscore the importance of resonance in explaining flood dynamics. By using sophisticated numerical computer programs, velocity fields (associated with resonance) near bottom relief can be simulated, placing us a step closer to explaining the sedimentary process in the building of the geologic column.

Dr. John Morris notes in his discussion that constant water depth, as postulated in the numerical calculations, is not a plausible assumption for a global ocean. Again, it was not the purpose of this paper to investigate all flood ramifications. An idea regarding the effects of uneven bottom relief and even shallow water regions on tidal resonance can be gathered from our previous calculations as given in Reference (5). The main tidal waves seem to be built up as they are with uniform depth, however, additional wave reflection from the bottom relief are superimposed on them (cp. Figure 4, Reference (5)).

Dr. Bernard Northrup would like for us to relate our results to the actual sedimentary column as seen at various places on the earth. We are not in a position to do so. Our goal, at present at least, is to show that a flooded planet will inexorably be subjected to certain periodic excitations which, in turn, will cause a predictable periodic response in accord with the laws of fluid mechanics. Other investigators will hopefully extend the concepts to specific situations as he has started to do in his discussion.

Prof. Robert Whitelaw also expects more than was intended from the study. A comprehensive explanation of all facets of *The Genesis Flood* can be speculated about and computer simulations

and other techniques can increase our understanding about some facets, but firm knowledge is an impossible desideratum.

One closing admission will help clarify the results shown in Figures 2 and 3: Since the co-authors conducted this research when widely separated from each other, a misunderstanding arose in the viscosity values to be used in the computer calculations. The kinematic viscosity units required (sq km/sec) are not common in engineering practice. As it turned out, the value selected ($v = 0.004$ km^2/sec) represents an extremely viscous fluid. It is little wonder that the tidal amplitudes calculated were much less than one would expect from a resonant condition. Recent calculations, using a kinematic viscosity corresponding to water ($v = 10E-13$ km^2/sec), resulted in a maximum tidal amplitude for a 60-degree latitude canal of some 300 meters (nearly 1000 ft) after some 225,000 sec. of real time. These calculations were started with a constant depth of water (5.12 km). Although the amplitude was still increasing when the calculations were stopped, a secondary wave was superimposing itself on the front side of the tidal bulge. Whether this occurrence signaled a true tidal wave action which developed at this large amplitude or was the beginning of a numerical instability has not been determined, The superimposed wave looked very similar to the secondary wave shown in Figure 10 of Reference (5). This further work will be reported at a later time.

M.E. Clark, Ph.D.
H.D. Voss, Ph.D.