TOWARD A CREATIONIST ASTRONOMY

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Abstract

It is noted that very little discussion of stellar evolution has been conducted from a creationist perspective. A brief summary of stellar structure and evolution is given with a few of the observational evidences usually presented. The question of how much fixity and change creationists should allow in stars is raised. It is argued that the theory of stellar structure appears to be founded on a good physical basis and that stellar evolution is intimately related to stellar structure. Stellar evolution, the name applied to the aging of stars, is a totally different case from biological evolution. The need of a complete creationist astronomy model is emphasized. Future discussion on these topics is encouraged.

Introduction

The modern creationist movement has made much progress over the past 30 years. This has coincided with the introduction of several periodicals and many books by numerous authors and various publishers. The general approach has been two-fold: first, to show that many observed properties of the world cannot adequately be explained by evolutionary or uniformitarian models, and two, to show that things can be explained better by the sudden creation of the world in the not so distant past. This second step has properly shied away from the response "that is the way God did it," in favor of the design and order that a benevolent Creator has ordained. When processes have been invoked, they have been ones of steady degeneration or of catastrophe.

The goal of all of this effort has been to produce a consistent and detailed alternate model that is Biblically correct and adequately describes what we observe. This work has progressed in the fields of biology and geology so that today we have a fairly well defined creationist model of each. The reviews of Gish (1975, 1989a, 1989b) show that these two fields have consumed the most attention of *Quarterly* authors since the inception of the Creation Research Society.

Astronomy is another science in which evolutionary and uniformitarian assumptions have had great sway, however a survey of creationist literature reveals that much less work has been done in this field as compared to biology and geology. Discussion has mainly involved five key topics:

Initial origin of the universe and solar system members
Age of things
Stellar evolution
Life in space
Anthropic principle of design

Of these, most of the work that has been done has fallen into two areas. One of these is the examination of the Moon, planets, comets, and other solar system objects to argue that they must have young ages (Humphreys, 1990). The other area leaps to the grand scale of the universe (cosmology) to argue against the standard, or Big Bang, model of the universe (DeYoung and Whitcomb, 1981). Since Big Bang cosmogony demands an ancient age for the universe, the purpose of this assault has obviously been to demonstrate that the universe does not necessarily have to be as old as currently thought.

We offer three criticisms of the present state of creationist thought in astronomy. First, as stated above, most attention has centered on the small scale (the solar system) and the large scale (cosmology), while leaving a rather large gap in scale between these. For example, the second Creation Research Society Monograph (Mulfinger, 1983) on design and origins in astronomy has only two sections of contributed papers, one on the universe and one on the solar system. Second, there has not yet emerged even a rough framework of an alternative creation model as we find in biology and geology. Third, except for teleological ramifications of the Earth's immediate environment, there does not seem to be any stress upon the purpose to the order and structure that we see in the universe. This last point seems to leave us with the uncomfortable position that the universe is as it is because God simply wanted it that way. As stated earlier, this has not been the general attitude prevalent in creationist studies of either biology or geology.

Actually, all three criticisms stem from the same root of a lack of a reasonably complete and consistent model, and the key seems to be the middle scale of criticism two. In general astronomical parlance this middle scale would be referred to as "stellar evolution" which purports to explain the structure of stars and to explain how and why they got to be in their present states. The use of the word "evolution" here carries a different connotation as it does in biology where an increase in complexity is implied. Instead, its astronomical use means change, whether the change is one of decay or perceived improvement. Furthermore, the evolution or change of stars is quite quantitative and is based upon well understood physical principles such as hydrostatic equilibrium, thermal equilibrium, equations of state of gases, and nuclear reactions. Still, the concept of stellar evolution is an attempt to explain the observed properties of the universe apart from the input of a creator. This, of course, should suggest caution to creationists. Indeed, Mulfinger (1973) has astutely warned

> . . . many professing Christians are being 'carried along with the tide.' Surely they fail to realize the consequences. There is no logical stopping point. The theory is a broad philosophical 'pathway' leading ultimately to atheism.

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Because of this danger, some creationists maintain the absolute or nearly absolute fixity of stars. The well observed occurrence of novae and supernovae should show that some change or evolution occurs. It is usually responded that these processes demonstrate that the evolution that we see is that of degeneration. But does not that conclusion stem from the general belief that such eruptions are from dying stars? And how do we know this? The study of stellar evolution tells us. Many creationists seem quite willing to accept certain conclusions of stellar evolution, while rejecting out of hand much of the theory leading to these same conclusions.

We feel that the whole topic of stellar evolution needs detailed examination from a creationist viewpoint, and it is hoped that this article and others to come will spark much interest and discussion in this journal and elsewhere. To be quite fair, there have been some attempts in the past, but they have not been of the scope that we feel is necessary. For instance, Wilt (1983) in his discussion of nucleosynthesis briefly described the major aspects of stellar evolution without offering many specific criticisms or alternatives. Mulfinger (1970) in a critique of stellar evolution identified a few problems in the theory current over 20 years ago; we are recommending that this work be updated and expanded.

As stressed earlier, one of the first issues that should be discussed is how much change in stars should we be willing to grant. It is not prudent to come to a hasty decision on this subject. Stellar evolution computer codes begin with models of stellar interior structure, which in turn rely upon well understood and very quantitative laws of physics. Complete rejection of stellar evolution would erode confidence in current understanding of stellar structure and would seem to repudiate much of physics as well. If creationists wish to scrap stellar evolution completely, then it is incumbent on us to rework stellar structure and/or physics in a convincing fashion. The present authors are not entirely certain about what, if any, should be kept, and we welcome discussion with other interested parties on this subject.

A Synopsis of Stellar Structure and Evolution

A brief summary of stellar structure and evolution would be appropriate at this point. For further study the reader is directed to the following recent review by Iben (1991) or to the standard texts in the field: Clayton (1968), Cox and Giuli (1968), Kippenhahn and Weigert (1990), Novotny (1973) and Schwarzchild (1958). We will not discuss here the birth and early development of stars, but instead start during the stable part of a star's lifetime. The fundamental problems with stellar birth have been discussed previously and perhaps we will return to this issue in a future paper.

The standard observational tool used in studying stellar structure and evolution is the Hertzsprung—Russell (H-R) diagram, so called because it was independently discovered by two astronomers by those names early in this century. It consists of a plot of stellar luminosities versus stellar temperatures, with luminosity increasing upward and temperature increasing to the left. Both quantities are plotted logarithmically. A schematic diagram is shown in Figure 1.

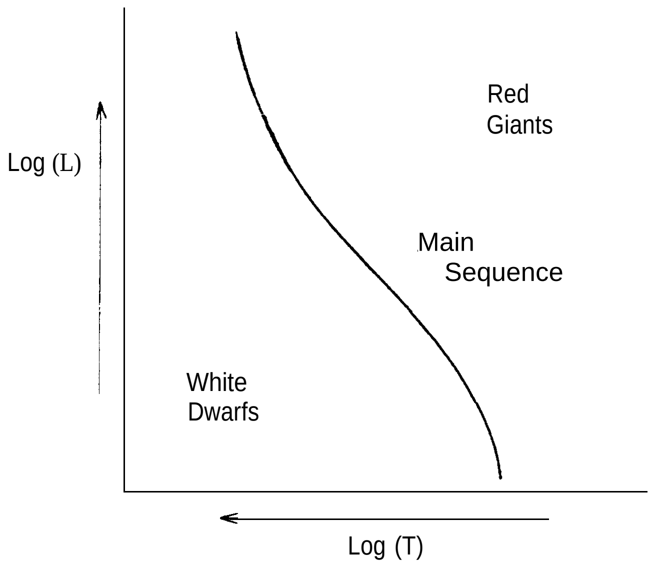

Figure 1. Schematic Hertzsprung-Russell Diagram. L is star luminosity; T is temperature.

Most stars are found on a roughly diagonal band called the main sequence (MS), while some stars are found in the upper right part of the diagram and a few are found to the lower left. The former are called red giants, while the latter are called white dwarfs. These names are appropriate because of the colors of these stars (reflecting temperature) and their sizes, which can be deduced with the following equation:

$$L = R^2T^4,$$

where L is a star's luminosity, R is the radius, and T is the surface temperature, and all variables are in solar units (L = R = T = 1, for sun). Notice that the above equation is very strongly dependent upon the temperature: a star to the right of the HR diagram has a low temperature and hence should have a low luminosity, while a star to the left has a high temperature and so should have a high luminosity. Stars to the upper right and lower left violate this trend, and this can only be if they are very large and very small respectively. White dwarfs are about the size of the earth, about 100 times smaller than the sun, while red giants may be hundreds of times larger than the sun.

A stellar interior model gives quantitative values of several physical quantities, such as temperature, density and pressure, at regularly spaced intervals inside a star. There are several assumptions, such as spherical symmetry, hydrostatic equilibrium, thermal equilibrium, an equation of state, nuclear energy generation processes, and radiative and convective energy transport. Each of these principles comes from well understood physics and finds applications in other fields. The equations can be expressed in differential form and must be solved simultaneously with boundary conditions that the star has the observed luminosity and temperature at its surface. Because the solution relies upon the use of a numerical integration scheme, much progress has been made since the invention of modern computers.

Early in the development of astrophysics the Russell-Vogt theorem was proved, which states that the structure of a star and hence its location on the H-R diagram is determined by the star's mass and composition. Further, it was shown that MS stars are consistent with models of stars having general cosmic abundances (mostly hydrogen and helium, with only a few percent by mass of everything else) and deriving their energy from hydrogen to helium conversion in their cores. Creationists have described possible gravitational contraction of the sun and other stars (DeYoung and Rush, 1989). This may indeed occur in certain stars, but the extreme temperature and pressure of stellar interiors assures that nuclear fusion is a major energy source. Even with only simple models this can be shown, as well as several predictions about the MS. First, the most massive stars are found to the upper left of the MS, while the masses gradually decrease toward the lower right. Furthermore, there should be a relationship between the mass and the radius (M-R relation) and a relationship between the mass and the luminosity (M-L relation). Stellar masses can be determined from studying binary stars, while radii and luminosities can be deduced from a couple of different methods each. Good observational data exist for a few score MS stars, to which the three model predictions above agree quite well.

This agreement is quite impressive and the physical assumptions that go into it are so well founded it is doubtful that many creationists would have much to argue with in MS stellar structure. However, what is generally called post MS evolution is not far removed from the brief outline of stellar structure given above. As thermonuclear reactions occur, the composition of a star will gradually change with time. A grid of stellar interior models for a given mass but reflecting the composition changes shows the gradual development or evolution that one would expect from the models. It would appear that acceptance of stellar structure involves a step or two down the slippery slope to which Mulfinger's quote referred. With that warning, let us turn to post MS development as suggested by stellar structure. We are not denying that stars were made on the fourth day of creation, complete with variety and maturity. This view of an instantaneous, fully functioning universe can readily be built into a creationist model of astronomy. The point that stars, in whatever initial stage of development, will naturally change due to energy considerations, if time permits. The rate of change, of course, is a critical variable of great interest to creationists.

Recall that the Russell-Vogt Theorem states that a star's mass and composition determine where a star is located on the H-R diagram. On the MS the compositions of stars are believed to be about the same (mostly hydrogen and very little of elements heavier than helium), so that mass is the only important determinant. Eventually all of the hydrogen in a star's core will be exhausted, and conversion to helium will commence in a shell surrounding the core. Without a nuclear energy source and accreting matter, the core will slowly contract, increasing the density and temperature of the helium core. Note that the composition has been radically changed from that of originally being nearly all hydrogen. The contraction and heating of the core will cause the outer layers to expand and cool, so that the star will move to the upper right in the HR diagram and become a red giant.

How far a star progresses past the red giant phase depends upon how much mass it has. Most stars have enough mass so that the temperature and density of the core increases until helium begins to fuse in the triple alpha process, called such because three helium nuclei (alpha particles) come together to form a carbon nucleus. With a renewed nuclear energy source, the contraction of the core is reversed for a while and the outer layers are restructured so that the star moves back down toward the left in the H-R diagram to a horizontal branch above the MS. Eventually the helium in the core is exhausted, and hydrogen to helium and helium to carbon fusion occurs in shells concentric with the carbon core. The process of core contraction is repeated and the star once again swells to a red giant along a path called the asymptotic giant branch. The most massive stars may pass through successive steps of fusing helium nuclei with increasingly more massive nuclei up to iron. Beyond iron, fusion reactions are generally endothermic (requiring energy) and so cannot be tapped as a fuel source for stars. Note that these transitions have not actually been observed. However, they are based on physics principles and will naturally occur. The lifetimes and rates of change of star stages might be a fruitful area for creationists to challenge current models.

About 35 years ago it was realized from the models that the cores of some of the giant stars should be electron degenerate, which suggested that these stars may be progenitors of white dwarfs. Degeneracy arises with great density, when electrons move freely in the stellar core. The atomic nuclei themselves are tightly spaced in a regular crystalline lattice-like arrangement. Twenty years earlier it had been demonstrated that electron degeneracy pressure could account for the very compact structure of white dwarfs (Chandrasekhar, 1939). It was felt that if the outer layer could somehow be ejected, then the core left behind would be a white dwarf and we would have a plausible explanation of their origin. Observations of red giants reveal that they experience large outward "winds" that can cause large mass loss over some time. Furthermore the relatively small surface gravity of red giants would allow for any instabilities to remove mass at a great rate. The exact mechanism is not quite known, but most astronomers agree that a red giant can eject a large amount of mass at some point, leaving behind a white dwarf that is surrounded by the ejected gas that we would see as a planetary nebula. In the past 25 years a picture has emerged for the most massive stars: their electron degenerate cores exceed the upper limit (1.4 solar masses) that electron degeneracy can support, and the resultant collapse to a neutron star or black hole gives rise to the explosion of a type II supernova.

Observational Predictions of Stellar Evolution

The theory of stellar evolution only briefly summarized above can be used to make some predictions that can be tested by observations. A back of envelope calculation can be done to determine how long a star will remain on the MS if the assumptions above are correct. It is generally assumed that about 10 percent of a star's mass is in the core and hence available for nuclear processing. Most of that material (more than

70 percent) will be hydrogen, and we know that 0.007 of the mass will be converted to energy when hydrogen is fused into helium. Using the mass and luminosity of the sun yields a MS lifetime of 10 billion years. More massive stars are higher on the MS, and though they have more mass available for fuel, their luminosities are so much greater that their lifetimes are significantly less. Less massive stars have somewhat less fuel, but their luminosities are much less, so that their MS lifetimes are much longer. The upshot is that the most massive stars have MS lifetimes of only a few hundred thousand years (of course, still much longer than young-age creationists would allow), while the lowest mass stars have MS lifetimes approaching 100 billion years.

Suppose that we consider a group of stars that form from a cloud of gas at about the same time, but having different masses. Because the cloud would be expected to be thoroughly mixed, the stars should have about the same composition. Exactly where the MS for such a group of stars occurs on the H-R diagram depends on the composition: a high metal abundance (elements heavier than helium in astronomy parlance) shifts it slightly to the upper right, while a low metal abundance shifts it slightly to the lower left. For a given composition, the locus of all masses where stars first appear on the MS is called the zero age main sequence (ZAMS). As stars "age" on the MS they will hook slightly upward to the right from the ZAMS, as shown in Figure 2. This is caused by the change in composition from the thermonuclear reactions occurring in the core. Upon the exhaustion of hydrogen in the core the star will move into the red giant region. Because of the greatly increased energy requirements of a giant star and the diminishing efficiency of post MS nuclear reactions, the lifetime of the giant phase is only a small fraction of the MS lifetime.

Notice that because the upper MS stars have the shortest lifetimes, they will be the first to turn off from the main sequence. The point at which this occurs is called the turn off point (TOP), and it will be located at progressively lower levels on the HR diagram

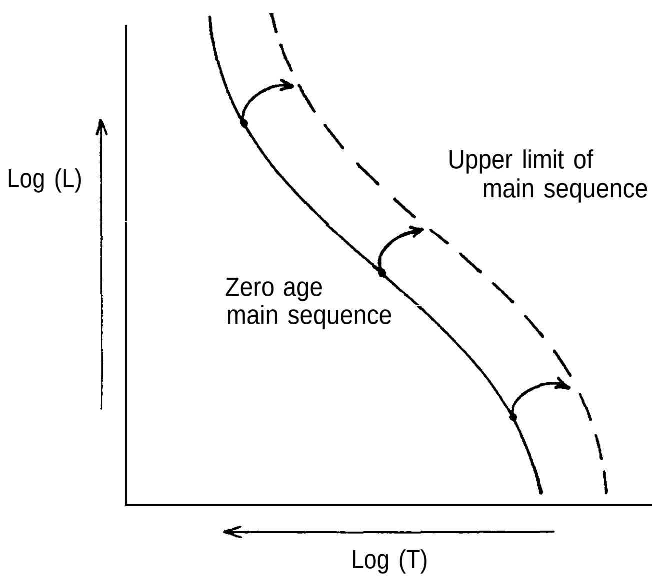

Figure 2. Theoretical path of stars from the Zero Age Main Sequence through the Main Sequence band.

with the passage of time. Therefore if a collection of stars having the same age and composition is compared to a different collection of stars having another common age and composition, the theoretical prediction can be compared to reality. If one is convinced of the basic correctness of the theory, then this method can be used to probe the ages of star clusters.

Where do we find stars of the same age and composition? An evolutionary assumption concludes that the stars in a star cluster should form from a single cloud so that the members represent such a homogeneous group. Different clusters should have different ages, and though they technically have different compositions, even large differences in composition do not seriously affect the overall appearance of an H-R diagram. Generally, the observations of stars in a cluster consist of colors and magnitudes, which must be converted to luminosities and temperatures. This process involves steps such as estimating the distance to the cluster, correcting for interstellar absorption and reddening from dust, and considering the effects of stellar atmospheres. This process has been done for a number of clusters, and the agreement of the theory is quite impressive, though one wonders how much the theory has been guided along by knowledge of the data to be fitted. Figure 3 shows schematic diagrams for a "very young" (100 million years) open cluster and a "very old" (15 billion years old) globular cluster. Note that the globular cluster has well defined red giant and horizontal branches. This is because globular clusters contain larger numbers of stars than open clusters and have TOP's in a region that show these features well.

Globular clusters are generally believed to be of about the same age (15 billion years) while open clusters are believed to have a much wider dispersion of ages up to 6 or 7 billion years. Additional arguments for the relative ages of the two types of clusters stem from kinematic and abundance studies, which spring from a general scenario of galaxy formation and history, which is an evolutionary model in itself. Stars that are now old formed early when gas was not confined to the galactic plane, while younger stars formed after gas collapsed to form the disk. Thus open clusters are found in the galactic disk and globulars are found in the halo of the galaxy. Because of the chemical enrichment of the interstellar medium that occurs when stars expel processed material when ejecting a planetary nebula or during the eruption of a supernova, stars that formed early would be expected to have low metal abundance, while later stars should have higher metal abundances. Such a trend between globular and open clusters is observed.

Evidence that the formation of planetary nebulae and the evolution of white dwarfs are related is usually given in the correlation of the estimated ages of those two types of objects. The structure of white dwarfs show that they cool over time, rapidly at first and more slowly as time progresses, and the rate is very similar for all white dwarfs so that the temperature roughly reveals the age. Spectroscopic measurements of a planetary nebula reveal how rapidly the gases in the nebula are expanding. If the size of the nebula can be measured, then the expansion can be extrapolated into the past to roughly reveal the age. These two ages have a very good correlation, that is, the

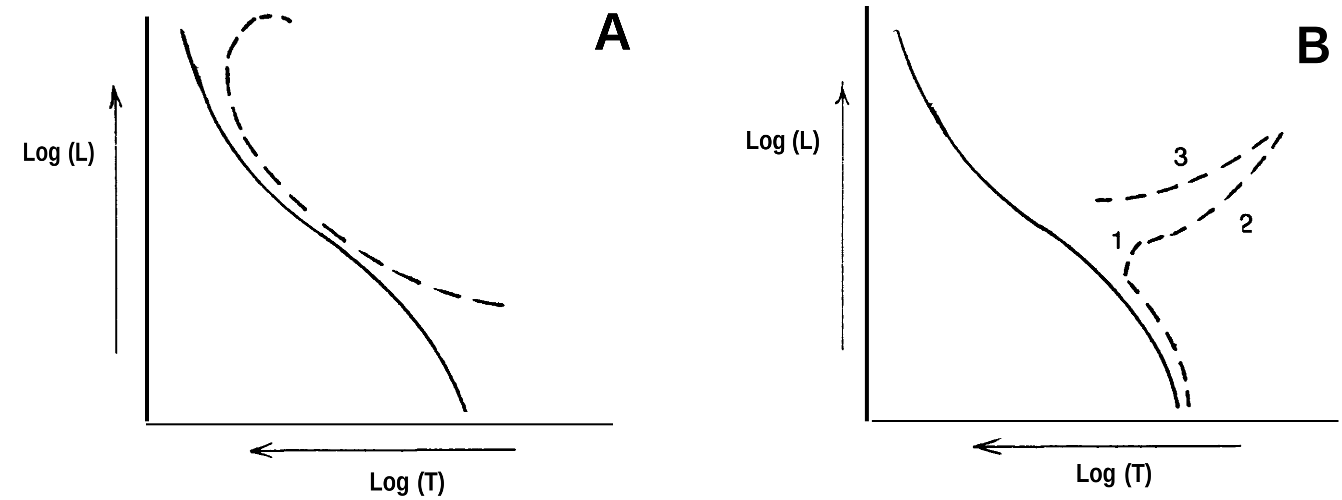

Figure 3. Schematic Hertzsprung-Russell diagram for a very "young" open cluster (A) and an "old" globular cluster (B). On each graph the zero age main sequence is indicated by a solid line and the turn off point by the number 1. On the globular cluster plot the Red Giant branch is indicated by the number 2 and the horizontal branch by the number 3. Note that the turn off point for the open cluster is much higher, and that its stars at the lower end lie above the main sequence.

younger planetary nebulae are associated with the younger white dwarfs, and the older planetary nebulae are associated with somewhat older white dwarfs. All planetary nebulae seem to have a white dwarf at the center, but not all white dwarfs are surrounded by a planetary nebula. How can this be? Planetary nebulae exist for only a brief time before the gases of which they consist are dispersed into the interstellar medium. The oldest planetary nebulae have estimated ages of only a few tens of thousands of years. On the other hand, white dwarfs last a very long time, virtually forever. So the white dwarfs that do not have an associated planetary nebula are simply old enough to have lost the nebula.

A similar relationship holds for neutron stars and supernova remnants. As with planetary nebula, the expansion velocity and observed size of the remnant can be used to estimate the time since the explosion. For example, the Crab Nebula has an age of about 950 years. and it has the same position of a supernova observed in the year 1054. The explosion of a supernova is believed to usually result in a neutron star, which is too small to be ordinarily observed. However, neutron stars generally emit beams of light from their magnetic poles, and the very rapid rotation of the tiny star causes a sort of search light of radiation to sweep out a conical shape. If we happen to lie near that cone, we can observe the periodic flashes of light, and the star is called a pulsar. Even with the seeming improbability of being situated near the cone, more than 300 pulsars are known, with periods on the order of a millisecond to a few seconds. The rotational kinetic energy is the source of energy for the beam, and so the period must increase with time. The rate of change in the period normalized to the period, or $\dot{P}/P$, is directly related to the pulsar's age. Where a pulsar can be identified in a supernova remnant, the ages of the remnant and the pulsar are well correlated.

Conclusion

Very brief discussions of stellar structure and evolution have been presented. Though it would seem that creationists would not have much with which to quarrel in the former, most would largely dismiss the latter. However, the two are intimately related, and one cannot be rejected without seriously calling into question the other. We are appealing to readers to give much attention to the study of stellar evolution, and we hope that much lively discussion follows.

A number of issues must be addressed. One of the most important is the question of how much change in stars should a creationist be willing to grant. Absolutely no change does not seem to agree with obvious observations. On the other hand, acceptance of most of the stellar evolution with its required vast ages is not acceptable. A related issue involves the time scales and rates of change which result from stellar models. These figures are certainly open to question, but the task is not simple. If competing creation models are to be presented, then sophisticated, original computer work lies ahead. Finally, the question arises upon what physical grounds will rejection of any part of stellar structure or evolution be done. This requires that an alternative be offered for each part, the sum of which should provide some guidance toward a creationist astronomy.

This is indeed a daunting task, one not to be taken lightly. We plan to publish further papers, but we certainly welcome correspondence from interested parties in the meantime.

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EROSION OF THE GRAND CANYON OF THE COLORADO RIVER PART I — Review of Antecedent River Hypothesis and the Postulation of Large Quantities of Rapidly Flowing Water as the Primary Agent of Erosion

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Abstract

One interpretation of the erosion of the Grand Canyon is reviewed—the antecedent view of the Colorado River cutting through the rising landscape. It is postulated that rapidly flowing water laden with abrasive particles moving from higher regions into lower areas was the main erosive agent in the formation of the Grand Canyon and that this erosion occurred rapidly within recent times.

Introduction

The Grand Canyon defies description because of its immensity and barren beauty. Even more so its history and the origin of the Colorado River that runs through it have led to considerable speculation and many differences of opinion. When one sees different portions of the Canyon, one can understand why there is so much variation of interpretation. If one has seen only the eastern end of the Canyon at the visitor centers, he is in for a shock when he visits the western portions of the Canyon. (See Figures 1-4.) Such was the authors' reaction. In many aspects it is similar to viewing two different canyons. It takes hours of walking to reach the Colorado River in the eastern Canyon. Likewise trying to reach the Shiva Saddle from the North Rim with a limited supply of water in extremely hot weather is very difficult (Meyer, 1987; Meyer and Howe, 1988). By contrast, you can drive down into the western Grand Canyon through Peach Springs Canyon. One feels as if not enough energy has been expended to achieve the goal or he has not placed himself at sufficient risk!

Because of the barrenness of the region, (Figure 5) the geology of the various formations can be examined in detail if one can reach the area of study. This differs from so many areas in the eastern United States when only an occasional window (fenster) can be found to study the arrangement of the geological formations. Thus the Colorado Plateau has attracted many people to do geological work because of the abundance of opportunities for observation. Uniformitarian scientists as well as catastrophist scientists have studied the area. We review one of the interpretations as to how the Grand Canyon formed and postulate the major causative agent for erosion—rapidly flowing water. Later papers will discuss other interpretations of formation as well as other processes involved in the formation of the Canyon. In mentioning time estimates, the authors are quoting the opinions of various workers involved. We do not subscribe to the geologic timetable.

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John Wesley Powell's Views

The first widely accepted explanation of how the Grand Canyon originated was elucidated by Major Powell, a one-armed Civil War veteran who led an expedition by boat down the Colorado River in 1869. As Collier (1980, p. 34) claimed:

> Powell advanced the notion that the Kaibab Plateau rose against an already established Colorado River. The River would have cut through the Plateau like a stationary saw cuts through a rising log.

Or in Powell's own words (1961, pp. 89,90),

> . . . Over the entire region limestones, shales, and sandstones were deposited through long periods of geologic time to the thickness of many thousands of feet; then the country was uplifted and tilted toward the north; but the Colorado River was flowing when the tilting commenced and the upheaval was very slow, so that the river cleared away the obstruction to its channel as fast as it was presented, and this is the Grand Canyon.

Thus Powell believed that the Colorado River existed prior to the uplift [antecedent to the structures in the Grand Canyon area] (McKee, et al., 1967, p. v) originating as far back as Tertiary times (Blackwelder, 1934, p. 554). As Nations and Stump (1981, p. 88) state, ". . . Powell the first to run the Colorado River through the Grand Canyon . . . claimed that the river was there first and merely maintained its course as the Kaibab Uplift rose beneath it." Also this antecedent view was held by Dutton (1882). Likewise Usinger (1967, p. 187) seemed to support this view: