An Analysis of Astronomical Aspects of the Hydroplate Theory

Danny R. Faulkner*

Abstract

In his hydroplate model, Walt Brown makes a number of statements and claims concerning astronomical issues. Many of these statements and claims are incorrect and/or misleading. This study presents an analysis of these problems. It is left to others to judge the merits of the geological arguments of the hydroplate theory.

Introduction

For about 30 years, Walt Brown has developed his hydroplate theory of the Flood. This model proposes that the originally created earth had vast subterranean chambers of water. Between the Creation Week and the Flood, the subterranean chambers were heated, and the pressure increased. At the time of the Flood, these chambers erupted. According to the model, a portion of the water released was the source of much of the water during the Flood. However, much of the ejected water pierced through the atmosphere into interplanetary space. Most of this water later condensed to form asteroids, comets, meteoroids, and some of the satellites of the outer planets. Thus, in the hydroplate model, these bodies did not exist from the original creation but instead originated as a result of the Flood. In this paper we will examine many of the claims of the hydroplate model that involve astronomical issues. We will leave it to others to evaluate the terrestrial geology claims of the hydroplate model.

Brown has reached a large lay audience with his website and his book, *In the Beginning* (Brown, 2008). Since 1980, up unto the writing of this article, this book has gone through eight editions. Since the website can be updated at any time, the quotes in this paper come from the eighth edition (Brown, 2008) of the book. This present paper came about from an interaction I recently had with Dr. Brown. He took exception to some critical comments that I had made on the CRS Internet discussion group. A few brief e-mails ensued, followed by a lengthy phone conversation. A few months later, he learned that I was traveling near his home and graciously invited me to come by for conversation with a few other people, a conversation that lasted more than two hours. Afterward, we exchanged several lengthy e-mails. In those e-mails I attempted to resolve with him some of the issues raised here, but these attempts met with little success.

Cometary Water from the Earth?

Brown (2008, pp. 274–275) notes that water is a major constituent of comets and that water is common on the earth.

> About 38% of a comet's mass is frozen water. Therefore, to understand comet origins, one must ask, "Where is water found?" Earth, sometimes called "the water planet," must head the list. (The volume of water on Earth is ten times greater than the volume of all land above sea level.) Other planets, moons, and even interstellar space have only traces of water, or possible water. Some traces, instead of producing comets, may have been delivered by comets or by water vapor that the fountains of the great deep launched into space.

Water is more abundant in the cosmos than Dr. Brown gives it credit for, and it is less abundant on earth than he implies.

* Danny R. Faulkner, Answers in Genesis, Petersburg, KY, dfaulkner@answersingenesis.org
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Water not only exists on other planets and satellites but also exists in the interstellar medium (ISM) and in the atmospheres of cool stars. Taking the estimated mass of the earth's oceans and dividing by the earth's mass, we find that water makes up only 2.1×10^{-4} of the earth's mass. The fact that most of the earth's water appears to be on its surface is a bit misleading (though some water may exist in the earth's mantle, at this time we do not know how much, if any, exists there). Ganymede and Callisto (two of the four larger Galilean satellites of Jupiter) have densities of a little less than 2.0 gm/cc. This is consistent with their composition being about 50–50% mixture of water and ice. Together, they likely contain 100 times more water than the earth's oceans currently contain. By Dr. Brown's reasoning for the terrestrial origin of comets, a better case could be made for Ganymede and Callisto as the likely source of comets. Alternately, Ganymede and Callisto could have come from the earth too, but their masses are far too great for that. However, he remains silent on the origin of these two satellites, suggesting that he believes that they likely are primordial, that is, they date from the Creation Week. This is inconsistent, for Dr. Brown uses the high water content of the smaller bodies of the solar system to argue for a terrestrial origin.

For that matter, high water content is a common feature of smaller solar system bodies far from the sun. For instance, the densities of the smaller satellites of the Jovian planets we have been able to measure are between one and two, consistent with more than one-half composition being water. Pluto and its largest satellite Charon have density of about 2.0, suggesting half water, half rock composition. Again, high water content is a common feature of solar system objects far from the sun. Comets are solar system objects far from the sun. Rather than seeing that comets resemble the earth, it is clear that comets better resemble other solar system objects far from the sun. In fact, this coincidence of high water content of planets, satellites, and asteroids far from the sun and comets (which also are far from the sun) has suggested to evolutionary astronomers a common origin.

Noting that water figured greatly in the Flood, Dr. Brown considers it likely that sufficient water was ejected from the earth at the time of the Flood to produce all the comets. According to his model, the subterranean water was under tremendous pressure, sufficient to blast much of the water through the earth's atmosphere and into space. To do this, the water must achieve escape velocity from the earth (about 7 mi/s = 11 km/s) plus additional speed to overcome the sun's escape velocity. Consider this quote from Brown (2008, p. 277):

> To escape Earth's gravity and enter only a circular orbit around the Sun requires a launch velocity of 7 miles per second. However, to produce near-parabolic, retrograde orbits requires a launch velocity of 32 miles per second! Earth's atmosphere would offer comparatively little resistance at such speeds. In seconds, the pulsating, jetting fountains would push the thin atmosphere aside, much as water from a fire hose quickly penetrates a thin wall.

This last sentence is a huge assertion, offered without any justification or supporting calculation. For our purposes here, we will not question the high pressure in the subterranean chambers nor the mechanisms supposed to provide the tremendous pressure. Instead, we will treat the chambers as a black box and deal with issues following release of the jets. There must be some interaction between the jets and the earth's atmosphere, so an obvious question to ask is how much kinetic energy is transferred from the jets into the atmosphere. There are two obvious mechanisms that will transfer this kinetic energy.

Water moving at this speed is moving at Mach 150! This is beyond supersonic into hypersonic speeds. Modeling this properly would be very difficult. Such high speeds undoubtedly would produce tremendous turbulence. Turbulence will slow at least a portion of the water jet and transfer kinetic energy to the atmosphere. A portion of this energy transfer would cause some of the earth's atmosphere to be carried along into space as well, though this too would be difficult to model and hence estimate. There will also be other interactions between the jets and the earth's atmosphere. The leading edge of a jet will slam into the atmosphere, and the air in the way will have to be shoved out of the way via momentum transfer. However, as the leading edge of the jet transfers momentum to the air, it would then move more slowly. Material behind the leading edge will subsequently move faster than the leading edge, which will lead to a collision between the slower moving leading edge and the faster moving material immediately below. Of course, this collision will slow down the water below the leading edge, leading to collision with still more water lower in the jet. This cascading effect will cause the leading edge of the jet to spread horizontally. Eventually, the jet could penetrate through the atmosphere, but this pancaking of the leading edge of the jet is one way in which a large amount of kinetic energy transfers from the jets to the atmosphere.

Assuming that a jet eventually penetrated through the atmosphere, there will be a very large inrush of air toward the jet. The jet is a fluid passing through another fluid (the atmosphere) with large relative velocity. Since the jet is moving Mach 150 and the atmosphere is essentially stagnate, Bernoulli's equation will produce a very large pressure difference that will drive air into the jet. Calculation shows that the pressure difference is nearly one atmosphere, and that the resulting speed of the inrushing air is nearly the speed of sound. Once the inrushing air slams into the sides of the jet, there will be large viscous motions between the two. This is a second way in which kinetic energy from the jet will transfer to the atmosphere. When chaotic transfer of kinetic energy happens as with these two mechanisms, the kinetic energy is quickly randomized into microscopic motion of the particles. We recognize that random microscopic particle motion is heat, so we say that the kinetic energy is thermalized.

How much thermalization of the kinetic energy of the jets would have occurred? This is difficult to say precisely, for it would require very detailed computation, and it is doubtful that our current models would permit realistic computation anyway. So let us use a very common practice in physics and astronomy of doing a "back of envelope" calculation. Let us assume for the sake of argument that only one millionth of the kinetic energy of the jets would be thermalized into the atmosphere. This figure is probably far too conservative, and the percentage of thermalized energy transfer is likely far higher. We make the following assumptions.

- The total mass of the jets
- The average velocity of the jets
- The mass of the earth's atmosphere
- The specific heat of air

Assumptions 1 and 2 yield the total kinetic energy. Dr. Brown has already done this calculation for his estimate of the material (both water and rock dislodged by the water as it is ejected upward) required to account for comets, asteroids, and small satellites of the Jovian planets (Brown, 2008, p. 424). He found 1.7×10^{29} J. One millionth of this available energy is 1.7×10^{23} J. One can find the current mass of the earth's atmosphere by multiplying one atmosphere of pressure (roughly 10^5 Pa), by the earth's surface area, and dividing by the acceleration of gravity, 9.8 m/s^2. This yields a mass of approximately 5×10^{18} kg. The specific heat of air is approximately 1,000 J/kg C. The formula for heat transfer is

$$Q = c\ m\ \Delta T,$$

where Q is the available heat, c the specific heat of air, m the mass of the earth's atmosphere, and ΔT is the change in temperature of the earth's atmosphere. Solving, we find that the change in temperature is 34 C. Thus, assuming that only one millionth of the jet energy is thermalized to the atmosphere and that heat is distributed uniformly, we find an atmospheric temperature increase of 34 C. This is in addition to other heating mechanisms, such as from volcanic activity and the latent heat of vaporization from rainfall. This is an unrealistically high temperature increase, and it is doubtful that the energy transfer was this minimal. With more realistic energy transfer, it ought to be obvious that trying to pass this much matter through the earth's atmosphere at such speed is not possible.

The casual way in which he asserts that the jets from the subterranean chambers could so easily penetrate the earth's atmosphere is most remarkable in light of his conclusion that

> even with enough energy, the fragments must be large enough to pass through Mars' atmosphere. To see the difficulty, imagine throwing a ball high into the air. Then visualize how hard it would be to throw a handful of dust that high. Atmospheric drag, even in Mars' thin atmosphere, absorbs too much of the smaller particles' kinetic energy (Brown, 2008, p. 306).

With this conclusion, Brown dismisses the belief that some meteorites found on earth originated on Mars. Those rocks allegedly were blasted off the surface of Mars by Meteoroid impacts. Mars has an extremely thin atmosphere and less gravity than earth, but he claims that that thin atmosphere is sufficient to prevent rocks from being lifted off the surface of Mars. Yet, Dr. Brown thinks that much more massive jets of water could have penetrated a much denser terrestrial atmosphere as if the atmosphere were not there. Given that rock is denser than water and that, being a fluid, a water jet will fragment into small drops, water ought to be more susceptible to atmospheric drag than rock is.

Problem of Long Period Comets

It is very questionable whether enough matter could have been ejected from the earth to account for the comets and asteroids that we see. However, there are many other astronomical problems for the hydroplate model to overcome. For instance, there are many comets with orbital periods around the sun that are very long, on the order of a million years. Assuming, as Brown does, that the Flood was approximately 5,000 years ago, very long-period comets would not have had enough time to complete their first orbits and thus have returned to the inner solar system. We observe only a small portion of a comet's orbit near perihelion. From this small portion of the orbit, we can use Newtonian mechanics to compute the entire orbit. The most important orbital parameter for our discussion right now is the period (the semi-major axis is related to the period, and the other parameters, the eccentricity, inclination, arguments of perihelion and ascending node, will be important later).

The orbital period of any object depends upon the mass of the body about which the object orbits. Since comets orbit the sun, it is the mass of the sun, or more generally, the solar system, that determines the period. Since the sun's mass so dominates what we know about in the solar system, to a very good approximation, it is the mass of the sun that determines the orbital periods of comets. Dr. Brown argues that if we have underdetermined the mass of the solar system by as little as 0.17%, the comets that we think have periods on the order of a million years could have orbital periods of less than 5,000 years. Thus, extremely long-period comets could return to the inner solar system much sooner than we think, and very long-period comets are not a problem for a Flood only 5,000 years ago. Quoting Brown (2008, p. 276),

> The distance (50,000 AU) is in error. Comets more than about 12 AU from the Sun cannot be seen, so both the

> distances they have fallen and their orbital periods must be calculated from the small portions of their orbits that can be observed. Both calculations are extremely sensitive to the mass of the solar system. If this mass has been underestimated by as little as about 17 parts in 10,000 (about the mass of two Jupiters), the true distance would be 585 AU and the period only 5,000 years.
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> Where might the missing mass be hiding? Probably not in the planetary region. The masses of the Sun, planets, and some moons are well known, because masses in space can be accurately measured if something orbits them and the orbit is closely observed. However, if extra mass is thinly spread within 40–600 AU from the Sun (beyond Pluto's orbit), only objects outside 40 AU would be gravitationally affected. (Recall the hollow sphere result on page 270.) That mass, depending on its distribution, could considerably shorten the periods of near-parabolic comets, because they spend 99% of their time at least 40 AU from the Sun.

There are several issues that I must address in this critique, but first an understanding of the Oort cloud (the hypothetical source of long-period comets) is necessary. For a long time, astronomers have known that individual comets have relatively short lifetimes, so the existence of comets today suggest that the solar system is far younger than billions of years. About 1950 the Dutch astronomer Jan Oort tabulated the aphelia of all comets known at that time and noticed that many of them had aphelia at very great, poorly determined distances from the sun. More precisely, Oort plotted a histogram of comet aphelia and found a large number clumped near 1/a approaching zero. He reasoned that this clump might represent the source of comets. He estimated that a comet's maximum aphelion distance was about 50,000 AU, or else gravitational perturbations from other stars likely would remove the comet from the sun's grasp, so this is the basis of the 50,000 AU figure. According to Oort, the sun is orbited by a huge number of comet nuclei many thousands of AU from the sun. This roughly spherical distribution is the hypothetical Oort cloud. Being so far from the sun, the comet nuclei remain very cool and indefinitely retain their volatiles, even for billions of years. Occasional gravitational perturbations of other stars rob some of the nuclei of enough orbital energy so that those nuclei fall to perihelia close to the sun so that they flare up and appear as comets near perihelion. Thus, newly introduced comets from the Oort cloud replace older, long-period comets that burn out. About the same time as Oort's work, Gerard Kuiper offered his Kuiper belt, a hypothetical distribution of comet nuclei orbiting the sun just beyond Neptune, as a source of short-period comets. I have previously reviewed the Oort cloud and the Kuiper belt (Faulkner, 1997).

Regarding Brown's quote, he stated that the 50,000 AU figure is in error, and offered reference number 31 on page 287 as support. That reference is to a book by Sagan and Druyan (1985, p. 201) and reads:

> Many scientific papers are written each year about the Oort Cloud, its properties, its origin, its evolution. Yet there is not yet a shred of direct evidence for its existence.

Notice that this reference does not mention the 50,000 AU figure, but rather it is an acknowledgement that there is no direct evidence for the Oort cloud. Sagan certainly did not believe that the 50,000 AU figure was in error, so what Dr. Brown claims here is very different from what Sagan wrote.

Notice that Brown dismisses the possibility that the sun's mass could have such large error. Actually, the statement that the hidden mass is "probably not in the planetary region" is a gross understatement. We can compute masses using the generalized statement of Kepler's third law of planetary motion,

$$r^3 = (GM/4\pi^2)\ T^2,$$

where r is the semi-major axis of an orbit, T is the orbital period, G is the universal gravitational constant, and M is the mass. As Brown (2008) correctly points out in footnote 86 on page 292, since we do not know the precise value of G, we actually compute the product GM, rather than M. We can apply this law to the earth's orbit around the sun. In 1900, the earth's orbital period was known to 13 significant figures; it is probably known slightly better today. According to *Allen's Astrophysical Quantities* (Cox, 2000), we know the earth's semi-major axis to 11 significant figures. Applying differentials to the above equation, we can see that an error of Δr in r will affect the error in M, ΔM, as 3 Δr, and that an error in T, ΔT, will affect the error in M as 2 ΔT. Since r is known less precisely than T, the error in r will dominate the error in the mass of the sun. Thus, the error in the mass of the sun is on the order of one part in 10^{11}, eight orders of magnitude less than Brown's "17 parts in 10,000."

This point is significant, for Dr. Brown's calculation of a 0.17% error in mass determination, found in footnote 85 (Brown, 2008, p. 292), is based upon the sun's mass being in error, a possibility that he immediately dismisses in the text. The inclusion of this figure from an admittedly irrelevant computation is extremely misleading, amounting to a bait and switch. One could easily conclude from the text that this minimal mass error of 0.17% applies to the discussion of a possible mass distribution 40 – 600 AU from the sun. Let us do a simple calculation of how much mass would be required.

First, let us consider no significant mass distribution outside of the sun. In this case, the potential energy is

$$U_1 = -\,GmM/r,$$

where M is the mass of the sun, and m and r are the mass and distance of the comet from the sun at some time. The total energy will be

$$E_1 = K_1 + U_1,$$

where K1 is the kinetic energy. Now let us consider a second case where the sun is surrounded by a thin shell of radius R and having mass M'. In similar manner, let us call the respective energies of case two E_2, K_2, and U_2. The potential energy U_2 is a bit more complicated than U_1. It has the form

$$U_2 = -\,GmM/r - GmM'/R \qquad r < R,$$

$$U_2 = -\,Gm(M + M')/r, \qquad r > R.$$

Since we are considering a very long-period comet, the comet will pass between the two domains of this potential. As usual, $E_2 = K_2 + U_2$. Note that in the domain $r < R$, the two kinetic energies will be the same. That is,

$$K_1 = K_2 = K \qquad \text{for } r < R.$$

This fact will allow us easily to determine the difference between the total energies E_1 and E_2. Evaluate the energies just inside $r = R$ and take the difference:

$$E_1 - E_2 = (K - GmM/R) - (K - GmM/R - GmM'/R) = GmM'/R.$$

While the potential energies of the two cases differ and the kinetic energies differ for $r > R$, this difference between the two total energies will remain constant.

To find the perihelion distances of the two cases, we note that $K = 0$ at aphelion. Let a_1 be the aphelion distance of case one. We find

$$E_1 = -\,GmM/a_1.$$

Similarly, we find that if a_2 is the aphelion distance of case two that

$$E_2 = -\,GmM/a_2 - GmM'/a_2.$$

We note that $a_1 > a_2$, so we can evaluate the energy E_1 at $r = a_2$:

$$E_1 = K_1 - GmM/a_2,$$

where K_1 is the kinetic energy of case one at the position $r = a_2$. Taking the difference between these last two expressions and setting it equal to the difference between E_1 and E_2 previously found, we find

$$E_1 - E_2 = K_1 - GmM/a_2 + GmM/a_2 + GmM'/a_2 = GmM'/R$$

which reduces to

$$K_1 = GmM'(1/R - 1/a_2).$$

We can find an alternate expression for K_1 by evaluating $K_1 = E_1 - U_1$ at $r = a_2$:

$$K_1 = -\,GmM/a_1 + GmM/a_2,$$

where we have substituted $-\,GmM/a_1$ for E_1 as previously found. Equating these two expressions for K_1, we find, after some algebraic manipulation:

$$M'/M = (R/a_1)(a_1 - a_2)/(a_2 - R).$$

This expression relates the ratio of the mass of the hypothetical shell to the mass of the sun and the radius of the shell and the two aphelia distances of either case. Since Brown suggested a shell having an inner radius of 40 AU and an outer radius of 600 AU, let us take the average, 320 AU, for R. Brown (2008) used 50,000 AU for a_1 and 585 AM for a_2. Using these values, the mass ratio is 1.19, which is 700 times more massive than the 0.17% mass error that Brown claimed. The table displays values of the mass ratio for various values of R, in AU, keeping the aphelia the same.

R	M'/M
40	0.07
100	0.20
150	0.34
200	0.51
250	0.74
300	1.04
400	2.14

The closer the mass distribution is to the sun, the less mass that distribution needs. However, the closer the mass distribution is to the sun, the more easily it would be detected. Assuming what appears to be the minimum shell radius R = 40 AU would require a mass about 70 times that of Jupiter in the vicinity of Pluto. This is nearly a million Pluto-sized objects. We have modeled a thin shell here; a more realistic model would be a shell with some thickness. That would offer an additional parameter for a varying density in the shell. However, this would still not account for the much greater amount of mass required by Brown's model. While a yet undetected mass distribution could account for very long-period comets, until there is some evidence for the mass, this is nothing more than special pleading on Brown's part.

There are other restraints to consider. Many believe that the Flood was more recent than 5,000 years ago (such as the Ussher chronology). This would increase the mass required. Furthermore, comets of extremely long period have not just recently begun to show up; they have been known for centuries and probably even for thousands of years. If extremely long-period comets were seen in, say, Roman times (as appears to be likely), the time constraint would be far shorter and the required mass correspondingly increased.

In supporting his claim of extra solar system matter, Dr. Brown notes twelve strange pairs of comets in an essay on page 273. His Table 14 contains orbital information of the twelve pairs. Within each pair, the inclination, the argument of perihelion, and the argument of the ascending node are very similar, and one can easily see the similarity within each pair. One could easily conclude that the two apparitions in each pair are the same comet. However, the orbital periods of the comets in each pair generally are so long that one would not normally expect to see such a quick return (the time between apparitions of a pair is as little as a century, but most of the periods are at least hundreds of thousands of years). Brown suggests that each pair is indeed the same comet but that the actual orbital period has been greatly reduced by a circum solar system cloud of matter.

There are at least three problems here. First, if each of these pairs of comets is indeed only one comet that has returned after about a century, then this must further constrain the extra solar mass required to return these comets so quickly. As previously discussed, Brown (2008) argues that long-period comets must have periods of less than 5,000 years, but for these comets to return in only a century, the extra solar mass must be far greater than he has suggested. This fact seriously undermines his calculated figure on the extra solar mass.

Second, Dr. Brown has been very selective of his pairs. There are many such pairs and even multiple comets with similar orbits. Of particular interest are the Kreutz sun grazer comets. As the name suggests, these comets have perihelia very near the sun. The comets of the Kreutz family have very similar orbital elements. Notable members of this family include the great comets of 1843 and 1882 and Comet Ikeya-Seki, seen in 1965. The SOHO spacecraft recently has discovered many very small members of this group as well, though most of those bodies are so small that they do not survive perihelion passage. All of these comets share common orbital parameters. Dr. Brown is very selective in that he did not include the great comets of 1843 and 1882 and Comet Ikeya-Seki in his list of comet pairs, even though they share orbital parameters as well. He established his criterion for identifying two supposedly different comets as being one as having similar orbital elements. Yet even when a comet pair meets the criterion, he appears to reject their identification as a single comet solely on the basis that the two comets are too closely spaced in time to fit his model. Once one accepts that at least one comet pair (and the Kreutz family has many members) is not the same comet, then that seriously undercuts his argument about other pairs being the same comet.

A third problem with Dr. Brown's comet pairs is that while the pair members share common inclination and arguments of perihelion and ascending node, the perihelion distance is sometimes quite different. This is particularly true of the third, fourth, fifth, and ninth pairs. Perihelion distance probably is the most difficult of the orbital parameters to alter by a single pass through the solar system, so it is difficult to believe that some of the supposed identical comets are in fact single comets.

Hydroplate Theory of Comet Composition

Comets contain a large amount of water ice, along with ices of various other substances, such as carbon dioxide and methane. Mixed with the ice is a great amount of microscopic particles that we call dust. Dust consists of rocky material, so while the ices would normally melt on earth, the dust would not. Dr. Brown makes a number of claims about comet composition that he says only the hydroplate model can explain. For instance, he states,

> Comets contain methane and ethane. On Earth, bacteria produce almost all methane, and ethane comes from methane. How could comets originating in space get high concentrations of these compounds? (Brown, 2008, p. 270).

Brown (2008) essentially argues that since methane on earth normally is biogenic, then the great abundance of methane in comets must necessarily be biogenic as well. Since in the hydroplate model, much material was removed from the earth at the time of the Flood, cometary methane originated on the earth. There are several points to make here. First, as implied in the quote above, not all methane is biogenic. In fact, some scientists, such as the late Thomas Gold, argue that much of the earth's natural gas (methane) is abiogenic. Methane is found in the ISM (many light years from earth), much too far away to have been contaminated from the earth, so interstellar methane appears to be abiogenic. Methane is found in the atmospheres of the Jovian planets, but Brown (2008) does not claim that the Jovian planets formed from material that came from the earth. Methane is abundant in the atmosphere of Titan, the largest satellite of Saturn, and there is good reason to expect much methane on the surface of Titan. He does not appear to believe that Titan originated from material ejected from the earth, so he should address the origin of methane on Titan. He could argue that Titan and the Jovian planets were contaminated by collisions of material ejected from the earth, but this would greatly increase the amount of material ejected from the earth.

He makes much of the presence of dust in comets claiming that "dust particles in comets vary in size from pebbles to specks smaller than the eye can detect. How dust could ever form in space is a recognized mystery" (Brown, 2008, p. 270). While some larger, pebble-sized dust likely exists in comets, the preponderance of the dust is in very small microscopic pieces. We can conclude this based upon two observations. First, dislodged dust from a comet nucleus forms a tail that is blown away from the sun by the sun's radiation. This effect works efficiently only on very small particles, and for the dust tail to be so easily visible requires a tremendous amount of those small particles. Second, rock-sized refractory particles from a comet ought to survive passage through the earth's atmosphere. The fact that no meteorites from shower meteors (known to come from comets) have been found strongly argues against any significant number of large pieces.

In the above quote, Dr. Brown touches upon a problem in modern astronomy: there is no mechanism whereby solid particles can easily form in the ISM. Thus, astronomers have suggested that much of the dust formed in the atmospheres of red giant stars, where the conditions of the material present, temperature, and pressure might allow for this. Stellar winds and radiation supposedly spread the newly formed dust into the ISM. Some of this dust then supposedly mixed with the hypothetical gas cloud from which the solar system formed. Therefore, the evolutionary theory is that the dust in comets came from the ISM, which in turn was manufactured by red giant stars. Brown (2008) seems to argue here that since it is impossible for dust to form in space, then the dust in comets must have come from the earth. However, dust is even more abundant than methane in the ISM. To be consistent, he should argue that interstellar dust must have come from the earth as well, but that dust is much too far away and far too plentiful to have come from the earth. The best that Dr. Brown can make of this is an argument against the naturalistic origin of dust in space. Yet, the presence of dust in comets hardly constitutes any evidence that the dust came from the earth as his claims.

Brown (2008, p. 270) makes several specific claims about cometary dust that are not true.

> In fact, the type of olivine in comet dust appears to be rich in magnesium, as is the olivine in rocks beneath oceans and in continental crust. In contrast, dust between stars (interstellar dust) has no repetitive atomic patterns; it is not crystalline, and certainly not olivine.

It is true at this time that interstellar dust generally does not appear to be crystalline while cometary dust does have some crystalline structure. This is strange, but evolutionary astronomers likely will come to explain this in terms of some reworking of cometary material early in their history – already the status of comets is being reconsidered for other reasons. Of more importance here is Brown's incorrect statement that olivine is not found in the interstellar dust. Olivine is a silicate containing Mg and Fe. Silicate is very common in the ISM, as evidenced by its spectral characteristics. Determining exactly which form of silicate is in the ISM is difficult, probably because it likely is a mixture of many forms. However, both Mg and Fe are very common elements, so we would expect that at least some of the ISM silicate is in the form of olivine. Furthermore, olivine, and even crystalline olivine, has been found in the ISM (e.g., see Waelkens et al., 1996).

In discussing the Deep Impact mission, Brown (2008, p. 276) states, "The cometary material blasted into space included: a. *silicates*, which constitute about 95% of the Earth's crust and contain considerable oxygen—a rare commodity in space."

It is not entirely clear whether Brown means that silicate or oxygen is rare in space. However, it does not matter, for neither is true. Oxygen is the third most abundant element in the universe, and astronomers have long detected it in the interstellar medium. Furthermore, compounds of oxygen, including solid silicate particles and rocks, are common in the universe. For instance, the moon and the three other terrestrial planets likely are rich in silicate rocks. Additionally, silicates are common in the ISM. Thus, as with dust, the presence of silicate material in comets does not demand a terrestrial origin for comets, and he claims that "sodium … is seldom seen in space" (Brown, 2008, p. 270). Again, this is incorrect; sodium is found in the interstellar medium.

In discussing the Stardust mission, Brown (2008, p. 270) states,

> The dust was crystalline and contained "abundant organics," "abundant water," and many chemical elements common on Earth but rare in space: magnesium, calcium, aluminum, and titanium.

Again, while some of these elements are depleted with respect to some other elements in the interstellar medium, actually they are plentiful there. Dr. Brown may have misinterpreted what he has read about the depletion of the elements magnesium, calcium, aluminum, and titanium in the ISM. These atoms are detected by their spectra in the ISM, which requires they be in a gaseous (or atomic) form. The depletion likely results from the metals being bound up in the dust in the ISM, thus reducing the amount of these materials available in the gaseous form. Silicates are very common in the ISM, so some of these metals, being common in silicates, must be in the form of dust. Brown (2008, p. 270) continues,

> What is "interstellar dust"? Is it dust? Is it interstellar? While some of its light characteristics match those of dust, Hoyle and Wickramasinghe have shown that those characteristics have a much better match with dried, frozen bacteria and cellulose—an amazing match.

The implication of this statement apparently is that since cellulose is biogenic in origin, then the presence of biogenic material in comets strongly suggests a terrestrial origin. Life does not exist in space. There are at least two large problems with this argument. First, Hoyle and Wickramasinghe (1978) were mostly discussing interstellar dust, yet Brown implies that their work referred to cometary dust. Again, if cometary dust must have terrestrial origin, then to be consistent, Brown ought to conclude that interstellar dust has a terrestrial origin (as stated, interstellar dust is far too distant and abundant to be from earth). The other problem is that Hoyle's and Wickramasinghe's claim is fairly controversial. There is little, if any, evidence for its support. Furthermore, their position on this subject was an attempt to bolster their theory of panspermia, which is that life originated elsewhere and was seeded upon the earth. Thus, their proposed direction of contamination was in the opposite direction of what Brown claims.

Brown (2008, pp. 270–271) discusses the fact that comets are enriched in deuterium.

> Water molecules (H_2O) have two hydrogen atoms and one oxygen atom. A hydrogen atom contains one proton in its nucleus. On Earth, about one out of 6,400 hydrogen nuclei has, in addition to its proton, a neutron, making that hydrogen—called heavy hydrogen, or deuterium—twice as heavy as normal hydrogen.
>
> Surprisingly, in comets, one out of 3,200 hydrogen atoms is heavy—twice that in water on Earth. Therefore, comets did not deliver most of Earth's water, as many writers have speculated. In comets, the ratio of heavy hydrogen to normal hydrogen is 20–100 times greater than in interstellar space and the solar system as a whole. Evidently, comets came from an isolated reservoir rich in heavy hydrogen. Many efforts by comet experts to deal with this problem are simply unscientific guesswork. No known naturally occurring process will greatly increase or decrease the heavy hydrogen concentration in comets.

Notice that Brown dismisses the evolutionary theory that the earth's oceans originated from comets on the basis that the deuterium abundances of comets and the earth's oceans do not match. It would seem that the same reasoning would eliminate the possibility that comets originated from the earth, as in Brown's model. Brown (2008, pp. 272, 279) addresses this.

> Comets are literally out of this world. As the flood began, the extreme pressure in the interconnected subterranean chambers and the power of supercritical water exploding into the vacuum of space launched material that later merged to become about 50,000 comets, totaling less than 1% of the water in the chambers. (These numbers will be derived later.) This water was rich in heavy hydrogen.
>
> Comets are rich in heavy hydrogen, because the water in the subterranean chambers was isolated from other water in the solar system. Our oceans have half the concentration of heavy hydrogen that comets have. So, if the subterranean chambers held half the water in today's oceans (as assumed on page 115), then almost all heavy hydrogen came from the subterranean chambers.

This is begging the question. Noting that comets are enriched in deuterium over terrestrial water, Brown is forced to hypothesize that the subterranean fountains were similarly enriched with deuterium in order to explain the deuterium content of comets. This is not a good explanation of the hydroplate model, as this latter quote expands upon an item in Brown's Table 16 (Brown, 2008, p. 275). How is his explanation of the deuterium discrepancy different from the "unscientific guesswork" of which he is so quick to accuse evolutionists?

Furthermore, the details of this argument are questionable. Measurements of deuterium in space and astronomical bodies are quite variable, even for the same objects. For instance, one study found that the deuterium abundance of Jupiter is 22 ppm (Lellouch, 2001), while another study found 600 ppm (Anonymous, 1996). These values bracket the terrestrial ocean value (154 ppm), as well as cometary values. Therefore, it is not at all clear what one could conclude from this. It could be argued that cometary deuterium came from Jupiter or that Jupiter and cometary deuterium came from the same source, conclusions quite different from those of Brown (2008).

Elsewhere Brown (2008, p. 271) states, "They contain limestone, clays, and some compounds found in or produced by life, such as methane." As previously mentioned, this contains an implied assumption that methane must be biogenic. Besides this, we must question the description of limestone and clays in comets. While some people have suggested that calcium carbonate may be in comets, that proposal is unclear and still debated. Clay refers to closely packed particles of small grain size. On earth, we think that clay normally results from weathering of rocks and compaction, all through the action of water. Given the porous nature of comets, it is not likely that small, clay-sized particles in comets are compacted sufficiently to resemble anything like terrestrial clays. Furthermore, it is not clear that any such particles must have involved liquid water in their formation, as on earth. In short, inclusion of mention of clay and limestone in comets is misleading at best.

Claims Concerning Comets

Brown (2008, p. 264) holds out comets as special harbingers of disaster.

> Fear of comets as omens of death existed in most ancient cultures. Indeed, comets were called "disasters," which in Greek means "evil" (dis) "star" (aster). Why fear comets and not other more surprising celestial events, such as eclipses, supernovas, or meteor showers? When Halley's comet appeared in 1910, some people worldwide panicked; a few even committed suicide. In Texas, police arrested men selling "comet-protection" pills. Rioters then freed the salesmen. Elsewhere, people quit jobs or locked themselves in their homes as the comet approached.

And elsewhere, he writes,

> Perhaps the founders of different cultures learned from their ancestors that comets were first observed right after the flood, so comets became associated with death and disaster worldwide—hence the word "disaster": dis (evil) + aster (star) (Brown, 2008, p. 279).

The etymology of the word "disaster" here is correct, but most lexicographers think that it has an astrological connection rather than exclusively applying to comets. While people have viewed the appearance of comets as portends of disaster, they have viewed the other astronomical events and objects with the sorts of bad things that Brown listed here as well. For instance, the Leonid meteor storm of November 12–13, 1833, caused many to think that the end of the world had come. One witness to this was a young Abraham Lincoln (Olson and Jasinski, 1999). Both lunar and solar eclipses have caused people to fear disaster. One example is Christopher Columbus's threat to Jamaican natives that if they did not bring him and his crew food that the moon would be taken away (Olson, 1992). At first, the natives rebuffed this demand, but when the moon was eclipsed later that evening (February 29, 1504), the fearful natives quickly complied. One rare example of natives using astronomical knowledge against natives is the famous case of Shawnee leader Tecumseh and his brother Tenskwatawa using information about the June 16, 1806 total solar eclipse to bring other Indian leaders into their line of thinking (Marschall, 1979). In passing, I will mention that I have had difficulty confirming that anyone committed suicide during the 1910 apparition of Halley's Comet; unfortunately, Brown did not reference this.

In discussing the Oort cloud, Brown (2008, figure 150, p. 269) stated,

> Mathematical errors led to the belief that a cloud of cometary material, called the Oort cloud, surrounds the solar system. … All we can say is that 71% of the long-period comets … are falling in with similar and very large energies.

It is not clear what Dr. Brown means by "mathematical errors" here. Is he referring to the possibility of circum solar system material (previously discussed here) that would greatly reduce the aphelia of what appear to be extremely long periods? If so, this hardly is a mathematical error. Rather it is more of an error of leaving out something that we do not know about, if one can call that an error.

Continuing with long-period comets, Brown (2008, figure 150, p. 269) writes,

> Few long-period comets would survive the many gravity perturbations needed to make them short-period comets. However, there are about a hundred times more short-period comets than one would expect based on all the gravity perturbations needed.

This and other statements suggest that Brown assumes that the evolutionary theory concludes that long-period comets are perturbed by the Jovian planets into short-period comets. However, astronomers generally no longer accept this position. For many years, many astronomers thought that this was possible, but computer simulations done during the 1980s showed that the conversion of long-period to short-period comets was far too inefficient to account for the number of short-period comets (see Faulkner, 1997 for discussion of this, with references to this work). Since then, astronomers generally have thought that while long-period comets originate from the Oort cloud, short-period comets come from the Kuiper belt. It is odd that Brown (2008) barely acknowledges the Kuiper belt, though he does use some of the data normally used to support the Kuiper belt as evidence of a circum solar system cloud of material.

Brown has made much use of some studies that suggest that the earth is continually bombarded by very small comets. This is very controversial, though not many reading Brown (2008) would pick up on this. His point is that these very small comets are found only near the earth and hence do not strike other planets.

> What can explain the strange characteristics of small comets, including their abundance and nearness to Earth, but not to Mars? Small comets have never been seen impacting Mars (Brown, 2008, p. 271).

First, the data supporting the conclusion about many small comets striking the earth's atmosphere are very controversial. Second, absence of evidence does not constitute evidence of absence. The data for the controversial idea of many small comets striking the earth's atmosphere come from certain satellites orbiting the earth and looking downward at the earth's atmosphere. While we have placed some satellites in orbit around Mars, none of those satellites have the instruments the earth-orbiting satellites have, which have produced data that have led some to conclude that there are small comets continually striking the earth. With its much thinner atmosphere, any such interaction of small comets with its atmosphere might be very different than on earth. If those bodies passed through the thin Martian atmosphere, the craters produced would be very small and are unlikely to be readily detected. Hence Mars may be pelted by these bodies as much as the earth is, if they are struck at all.

On another issue, Brown (2008, p. 271) states,

> Meteor streams are associated with comets and have similar orbits. Meteorites are concentrated in Earth's topmost sedimentary layers, so they must have fallen recently, after most sediments were deposited. [See "Shallow Meteorites" on page 38.] Comets may have arrived recently as well.

The meteoroids in meteor streams are clearly associated with comets. That is, from the measured paths of meteors in the atmosphere, we can compute the orbits that the meteoroids followed around the sun. In every case, the orbits are very elliptical and inclined, the kind of orbits that comets follow. In fact, in many cases we can identify the comets that are responsible for the debris. In other cases we cannot, but that is probably because the parent comet has expended all of its volatiles and no longer exhibits comet behavior. No one has recovered a fragment from a shower meteor. This is significant, for it means that the meteoroids responsible are very small and fragile, just the kind of thing that we would expect from what we know of comets. On the other hand, we frequently find meteorites from sporadic meteors. The measured paths of sporadic meteors in the atmosphere allow us to compute orbits of the meteoroids responsible. We find that those orbits have low eccentricity and low inclination, the kind of orbits that asteroids have. This is significant, because it strongly implies that comets and asteroids are very different bodies, contrary to what Brown states elsewhere. Furthermore, Brown's statement here is irrelevant, because unless comets have changed character tremendously since the Flood, we would not expect to see any meteorites originating from comets in sedimentary rocks.

In discussing a histogram of comet energies, Brown (2008, figure 150, p. 269) states,

> As you can see, ***near-parabolic comets are falling in for the first time***. Were they launched in a burst from near the center of the solar system, and are they just now returning to the planetary region again, falling back from all directions? If so, how did this happen?

One could question whether near-parabolic comets are falling in for the first time. However, if this is true, as many would agree (and certainly recent creationists), there are other possibilities. For instance, if comets were part of the original creation, then they were made pretty much as they now exist. Apparently, he believes that creationists must look for physical explanations for much of the world, disdaining suggestions from fellow creationists that some aspects of the physical world might date to the Creation Week.

Brown believes that comets had struck the surfaces of other bodies, but most obviously the moon, Mars, and possibly Mercury. For instance, in discussing recent studies that have suggested water frozen on certain parts of the lunar surface and the surface of Mercury, he writes

> How could so many comets have recently hit the Moon, and probably the planet Mercury, that ice remains today? Ice on the Moon, and certainly on hot Mercury, should disappear faster than comets deposit it today (Brown, 2008, p. 275, and restated on p. 280).

This is an assertion without support. There are crater floors on the polar regions of the moon (and probably on Mercury) where the sun never shines. The expected temperatures of these regions always are well below freezing, so ice could exist there for a very long time. In 2009, the LCROSS/LRO mission produced evidence that there indeed is water in these perpetually cold regions.

> On Mars, comet impacts created brief saltwater flows, which then carved "erosion" channels (Brown, 2008, p. 275).

Why must these be saltwater flows? Since salt is relatively common and so soluble in water, it would not be surprising to find that salt is in alluvial deposits on Mars, but saltwater is not necessary to form erosion channels. Freshwater erosion channels on earth are common. This statement is begging the question.

Claims about Meteorites, Asteroids, Planets, and Satellites

Since Dr. Brown supposes that the matter that makes up comets and asteroids came from the earth, he might expect to find evidence of life in these objects. Proponents of panspermia—that life originated elsewhere and was seeded upon earth—make the same prediction. He references the work of panspermia proponents in stating that "seventy-eight types of living bacteria have been found in two meteorites after extreme precautions were taken to avoid contamination" (Brown, 2008, p. 303).

This is indeed a startling and monumental result, of which I was fully unaware. Brown cites an obscure source (Gerachi, et al., 2001) to support this conclusion. The report was the publication of an oral presentation at a science meeting in Italy. Included with this report is a statement by referees and discussion of those who attended the presentation. The referees stated that they saw the first draft of the presentation scarcely a week before the presentation, and the final draft and illustrations one day prior to the presentation. Despite Brown's statement that extreme precautions were taken to avoid contamination, a very important portion of this discussion was concern about contamination. Quoting from the referees' report,

> The section on methodology, essential to ascertain the degree of possible contamination of the samples, is relatively lean, especially in the part concerning the preliminary treatment of the rocks (metamorphites, granitoids and granulites, meteorites). No matter how sterile might have been the operating environment of the biological laboratory, the previous history of the individual samples does not seem to have been investigated thoroughly, thus leaving room for doubt about the true

> representativeness of the samples under study. In particular, the first treatment of the samples with the diamond saw could have introduced extraneous (even organic) materials into the intergranular spaces; the subsequent washing with ethanol, followed by brief heating with the Bunsen burner flame might not have entirely removed such materials. Although not criticizing the procedure followed in the biological laboratory (which appears perfectly suitable for the degree of sterility required for normal terrestrial materials), the undersigned referees believe it appropriate to warn the authors about the need to strengthen their laboratory microbes in rocks and meteorites: a new form controls in relation to the possible contamination in a terrestrial environment of the surfaces and intergranular spaces of the extraterrestrial materials… (Gerachi et al., pp. 64–65).

Therefore, there is considerable question as to how much contamination took place. This work has not been published elsewhere, likely because the authors make a fantastic claim that they are not able to substantiate. Brown's use of this controversial material is highly questionable, and its inclusion surely leaves a very incorrect impression upon his readers. Incidentally, the supposed discovery of bacteria in meteorites is not a new story. For instance, 75 years earlier Lipman (1932) claimed to have found bacteria in meteorites.

Brown (2008) also has incorrect statements regarding the composition of asteroids. For instance, he writes,

> Question 6: Aren't meteoroids chips from asteroids?
>
> This commonly-taught idea is based on an error in logic. Asteroids and meteoroids have some similarities, but that does not mean that one came from the other. Maybe a common event produced both asteroids and meteoroids (Brown, 2008, p. 298).

This is not an error in logic. The similarities of asteroids and meteoroids include not only composition but also orbital similarities. Besides, this is the same sort of reasoning that Brown used to argue that comets came from the earth. That is, he argued that since comets contain water and small grain particles and that those things are found on earth, then comets must have come from the earth. Instead, this appears to be an error in logic on Brown's part.

Or consider this statement:

> Also, what accounts for the meteorite's other contents: potassium, magnesium, iron, and calcium—elements abundant on Earth, but as far as we know, not beyond Earth? (Brown, 2008, p. 303, from the essay, "Meteorites Return Home")

This statement is patently false. Potassium, magnesium, and calcium are found in abundance on the moon. We think that these elements, along with iron are common on Mercury, Venus, and Mars. Iron whiskers are common in the ISM. Furthermore, resonance lines of all four of these metals long have been detected in the interstellar medium (Draine, 2011, pp. 86–91). It is true that metals in the ISM are depleted with respect to solar and stellar abundances, but this is easily explainable in terms of grain formation, which must necessarily contain these elements (Draine, 2011, pp. 263–284). Potassium, magnesium, iron, and calcium produce very strong absorption lines in the sun's spectrum and in the spectrum of similar stars. In fact, the spectra of spiral galaxies are dominated by calcium lines. The calcium lines in galaxy spectra are the combination of spectral lines formed in the billions of stars that the galaxies contain. The calcium lines are the most common spectral lines used to measure redshifts of galaxies. For instance, Agafonova, et al. (2011) presented a study of three isotopes of magnesium measured at high redshift in the intergalactic medium.

Or consider this statement:

> Light spectra (detailed color patterns, much like a long bar code) from certain asteroids in the outer asteroid belt imply the presence of organic compounds, especially kerogen, a coal-tar residue. No doubt the kerogen came from plant life (Brown, 2008, p. 304).

As with statements about comets previously discussed, Brown assumes that organic compounds, especially ones frequently associated with living things, must be biogenic. However, kerogen has been detected in the interstellar medium and in circumstellar clouds. These clouds are much too far away to have been contaminated by material from the earth, so there must be an abiogenic source for kerogen.

In discussing red asteroids, Brown (2008, p. 304) states,

> Many asteroids are reddish and have light characteristics showing the presence of iron. On Earth, reddish rocks almost always imply iron oxidized (rusted) by oxygen gas. Today, oxygen is rare in outer space.

It is true, such as with Mars, that red color can indicate the presence of iron oxide. However, other compounds can produce red color, so it does not follow that red necessarily implies the presence of iron oxide. For instance, sulfur on the surface of Jupiter's satellite Io makes it appear red. It is not clear what Brown means by "light characteristics," but the spectra of red asteroids matches the spectra of carbonaceous chondrite meteorites well. The red apparently comes from organic compounds, and most astronomers think that red asteroids are the parent bodies of carbonaceous meteorites. Jupiter's famous Great Red Spot likely is colored by organic compounds too. Furthermore, contrary to what Brown states (as I pointed out earlier), oxygen is not a rare commodity in space.

With the mention of the red color of Mars, Brown (2008, p. 304) writes,

> Mars, often called the red planet, derives its red color from oxidized iron. Again, oxygen contained in water vapor launched from Earth during the flood, probably accounts for Mars' red color.

That is a possibility, but there are others. For instance, there is evidence that not only did water once flow on Mars but that there also may have been standing water to some considerable depth (seas). This would allow for oxidation of the surface. Brown (2008) discusses this with a focus on water flow, but he fails to mention water with depth as well. In a figure caption, he writes,

> These channels frequently originate in scooped-out regions, called amphitheaters, high on a crater wall. On Earth, where water falls as rain, erosion channels begin with narrow tributaries that merge with larger tributaries and finally, rivers. Could impacts of comets or icy asteroids have formed these craters, gouged out amphitheaters, and melted the ice—each within seconds? Mars, which is much colder than Antarctica in the winter, would need a heating source, such as impacts, to produce liquid water (Brown, 2008, p. 305, caption to Figure 163).

By concentrating on this sort of feature, Brown ignores the numerous examples of branching tributaries on Mars. In the photo that this caption accompanies, there is some branching on the slope walls. This erosion pattern is similar to what one sees on steep slopes in the American Southwest. Even if one were to restrict discussion to amphitheater erosion, as in Grand Canyon, there is much evidence that Mars was once much wetter and warmer in the past, so that a terrestrial origin of Martian water that Brown suggests is not required. Furthermore, recent evidence shows that liquid water may be flowing from underground even today without any kind of impact involved.

In discussing the origin of the satellites of the Jovian planets, Brown (2008, p. 301) writes,

> The smaller moons of the giant planets (Jupiter, Saturn, Uranus, and Neptune) are captured asteroids. Most astronomers probably accept this conclusion, but have no idea how these captures could occur.

It is false that astronomers have no idea how these captures could occur (see, for example, Horedt, 1976). It is true that a simple 2-body interaction won't suffice, because two bodies that interact gravitationally will remain in orbit if they are bound to one another but will pass on hyperbolic paths otherwise. There are two ways out of this problem. One way is to modify the 2-body interaction with some additional factors, such as tidal forces, or aerobraking, which we shall see is Brown's preferred method. The other way is to involve a third body. A simple gravitational interaction of two objects is very easy to solve in a closed form, but once a third body (or more bodies) is thrown into the mix, the problem becomes very intractable with too many variables. This is called the n-body problem, where $n > 2$. How this works is that as a small body passes close to a massive body, the massive body perturbs the path of the smaller body. If there is a third body (or more bodies) nearby, the perturbations of this extra body can rob the small body of enough energy so that the massive body can capture the small body into a stable orbit. On the other hand, this interaction can cause the small body to gain energy rather than lose energy, in which case there is no capture. The actual result depends upon the initial conditions, which we have no way of knowing unless we actually observe the capture. Since the Jovian planets have many satellites, some of them quite massive in their own right, n-body interaction for the capture of at least some of the smaller satellites is quite plausible. This is the same sort of interaction that Jupiter exerts on comets to shorten (or lengthen) their periods and to populate Jupiter's family of comets. It is ironic that Brown (2008, p. 278) does not recognize this possibility for satellite capture but invokes this for Jupiter's family of comets.

As for aerobraking, Brown (2008, p. 301) continues,

> As explained earlier in this chapter, for decades to centuries after the flood the radiometer effect, powered by the Sun's energy, spiraled asteroids outward from Earth's orbit. Water vapor, around asteroids and in interplanetary space, temporarily thickened asteroid and planet atmospheres. This facilitated aerobraking [see page 269] which allowed massive planets to capture asteroids.

This is not supported by the facts. First, aerobraking primarily works to circularize a closed orbit that already exists by lowering apsis, the most distant point on an orbit around a planet. Aerobraking can be used to slow and effectively capture a body, as has been done for spacecraft visiting other planets, but that requires a very carefully planned trajectory. One must question how frequently this could happen naturally with random trajectories.

Second, this works only for bodies that orbit or pass close to the planet's atmosphere. We do not know the thickness of Jupiter's atmosphere, but it is unlikely to be greater than 200 km. At this time, Jupiter has 63 known satellites. The innermost satellite, Metis, orbits at a distance of 127,690 km from the center of Jupiter. Jupiter's equatorial radius is 71,492 km, so Metis orbits more than 156,000 km above Jupiter's atmosphere. To have any effect upon this satellite, Jupiter's atmosphere would have had to have been expanded by a factor of nearly 300. Problems abound here. For example, addition of material to an atmosphere's such as Jupiter's will not appreciably swell the atmosphere. Mass added to the atmosphere will add weight, which will compress the lower part of the atmosphere to cause the lower atmospheric material to liquefy, thus occupying far less volume. Therefore, there would be no noticeable increase in the thickness of the atmosphere. Certainly, the atmosphere cannot magically resume its earlier configuration to hide what once happened, as Brown (2008) suggests.

Another problem is that a capture event normally ought to result in orbits that are very highly inclined and/or have high eccentricity and frequently are retrograde. In fact, this is a point that Brown (2008, p. 310, endnote 44) makes:

> The smaller moons of the giant planets tend to have irregular orbits. For example, Jupiter has at least 31 irregular moons, the largest, Himalia, is 150 kilometers (93 miles) in diameter. Their orbits generally have high inclinations and eccentricities. Many are retrograde. These characteristics show that they were captured.

The eight innermost satellites of Jupiter, including Metis and the four large Galilean satellites, have very low inclinations and low eccentricities. Themisto, the ninth most distant satellite from Jupiter, is the satellite closest to Jupiter that has an inclined, eccentric orbit. At a distance of 7,393,216 km from Jupiter, Themisto's average distance from Jupiter's atmosphere always is more than 7 million km from Jupiter's atmosphere, and Themisto never is within 5.7 million km. All the satellites that orbit Jupiter beyond Themisto have highly inclined and/or very eccentric and frequently retrograde orbits, the kind of orbits that likely resulted from capture events. The most distant satellite orbits more than 30 million km from Jupiter. It is absurd to suggest Jupiter's atmosphere ever swelled to produce aerobraking on these satellites, particularly when we recognize the fact that the much closer orbiting, very circular, low inclination orbit satellites would have been orbiting within the very thickest parts of the much expanded Jovian atmosphere. It is obvious that Dr. Brown has not sufficiently worked out any details of his proposed mechanism; else he would have determined these problems. Similar problems exist for the many small satellites of the other three Jovian planets. Generally, it is the distant satellites that have orbits suggesting capture, and the nearby satellites do not.

Miscellaneous Statements

Dr. Brown clearly disagrees with the 2006 decision of the International Astronomical Union (IAU) to demote Pluto's status as a planet, but his argument is poorly reasoned. First, he states that "the IAU had no jurisdiction to change the definition of 'planet' for the rest of the world" (Brown, 2008, p. 26). Founded in 1919, the IAU is the internationally recognized authority for assigning designation for all astronomical bodies. For instance, the IAU has developed rules for naming of features on planets and satellites, naming of asteroids and comets, and nomenclature for just about every other astronomical body. Included with this authority is the classification and definition of objects, including planets. So Brown is wrong in his belief that the IAU has no authority to do this.

Second, Brown implies that the IAU's motivation for reassigning Pluto as a trans-Neptunian object (TNO) is the difficulty in explaining some of Pluto's characteristics in an evolutionary scenario. This makes no sense. Simply calling Pluto something other than a planet does not remove any difficulties. Rather, there are some fundamental reasons why astronomers no longer view Pluto as a planet that have little, if anything, to do with evolution. See Faulkner (2009) for further discussion of reasons for Pluto's reassignment.

Third, Brown (2008) engaged in an ad hominem argument when he testified to how he had Clyde Tombaugh, the discoverer of Pluto, for a professor and what a wonderful man Tombaugh was. Whether Tombaugh was a nice gentleman or not is irrelevant to whether we ought to continue to view Pluto as a planet.

Brown (2008, pp. 30–31) dismisses dark matter on the basis that astronomers devised it in order to salvage the big bang theory. This is incorrect, though it is a very common misconception among recent creationists. For a discussion of this misconception, as well as a general treatment of dark matter within a creationary context, see DeYoung (2000). The first evidence for dark matter came from Fritz Zwicky's discovery of expanding clusters of galaxies in the 1930s. The best evidence for dark matter comes from the rotation curves of spiral galaxies pioneered by Vera Rubin in the 1970s. It was not until the 1980s that cosmologists began to seriously consider the effect of dark matter upon their models. This inclusion is driven by the fact that if dark matter dominates over the mass of lighted matter, then any cosmological model that excludes dark matter could not accurately describe the universe. What may confuse Brown on this issue are recent studies that have attempted to measure the amount of dark matter, albeit within a framework of the big bang theory.

Conclusion

I have identified a number of incorrect statements that Dr. Brown has made concerning astronomical data. I have also shown that many of his inferences and conclusions are incorrectly drawn or are just simply assertions. Thus, there is considerable doubt that the hydroplate model can explain the origin of comets and asteroids. There are many other possibilities within the recent creation framework to explain asteroids and comets, from their origin during Creation Week with little modification since to origin or extensive modification post-Creation Week. The points made here are entirely apart from any judgment concerning the geological and Flood aspects of the hydroplate model. It is desirable that those with expertise in geology will similarly evaluate the hydroplate model.

When I began this study, I had thought that the astronomical issues were tangential to the hydroplate theory, that these easily could be separated from the geology of the hydroplate theory. However, I have come to realize that perhaps the primary motivation for the hydroplate model is to explain solar system phenomena. If this is the case, then it is unlikely that Brown will abandon these aspects of his model.

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