The Proceedings of the International Conference on Creationism

Volume 6
Print Reference: Pages 293-306

Article 26

2008

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In A. A. Snelling (Ed.) (2008). Proceedings of the Sixth International Conference on Creationism (pp. 293–306). Pittsburgh, PA: Creation Science Fellowship and Dallas, TX: Institute for Creation Research.

Our Solar System: Balancing Biblical and Scientific Considerations

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Abstract

For young age creationists Scripture gives guidelines that give some direction for dealing with the scientific evidence. Yet, because of the many details Scripture does not address and the limits of the scientific data available, there is room for more than one interpretation of many details regarding the history of objects in the solar system. Some general guidelines are mentioned based on the Genesis creation account and these are applied to the specific case of our moon. Impact cratering as well as volcanism on the moon is discussed, with the author's approach to cratering compared to the views of Faulkner. It is argued that crater size-frequency statistics suggest that Earth, the Moon, Mars, and Mercury were all struck by a similar population of objects. The impacts on the moon are interpreted as resulting from one extended event that coincided with the Flood and continued into the post-Flood period. The planetary magnetic field model of Humphreys is applied to date the Imbrium impact on the moon at approximately 1,840 years after creation. Humphreys magnetic dipole moment figures for the moon are found to also be plausible for explaining lunar swirl features on a young moon. .

Keywords

Genesis, Creation, Cratering, Lunar volcanism, Radioactive decay, Ghost craters, Cryptomare

Introduction

Young age creationists have a commitment to the inerrancy of the Bible and also are committed to dealing with scientific observations realistically. Scripture gives us more information pertinent to Flood geology and the history of the earth than it gives us on the history of objects in our solar system (or the universe). Thus, as creationists attempt to tackle technical issues in astronomy, it is important to have some clear biblical direction to build upon. There is much Scripture does not address about what the initial conditions were on various objects in space at the end of the Creation week. Thus there is a need to clarify issues in astronomy where creationists have a certain latitude of opinion possible, where there is room for more than one interpretation of the data. Many issues in astronomy simply require more research by people with a young age creation viewpoint. Questions arise regarding the role of the supernatural in the Creation week, intelligent design in the solar system, the relevance of mankind's Fall on objects outside of earth, and the significance of changes in God's original creation since the beginning. The following will explain the author's approach to balancing biblical considerations on the above questions with scientific observations. After discussing some biblical principles, the geological history of our moon will be addressed as an example of applying a creationist approach in solar system studies.

The first biblical issue to consider is the Creation week. The following treats the Creation week as being six literal days (see Exodus 20:11). At the end of the Creation week God evaluated all He had created as very good and then there is the following familiar statement about creation being "completed."

> God saw all that he had made, and it was very good. And there was evening, and there was morning—the sixth day. Thus the heavens and the earth were completed in all their vast array (Genesis 1:31–2:1 NIV).

Undoubtedly unique processes were at work during the Creation week. The late Henry M. Morris described what he referred to as special creation as "(1) supernaturalistic; (2) externally directed; (3) purposive; and (4) completed" (Morris, 1974, p. 11). Whatever unique processes took place during the Creation week, they were completed before the seventh day. Henry M. Morris considered the Creation week to have included supernatural processes and then after the Creation week natural processes took over to preserve the order God created. Morris (1976, pp. 80–81) stated the following in *The Genesis Record*,

> The present processes of the universe are, without exception, processes of *conservation* and *disintegration*, as formulated in the two universal Laws of Thermodynamics. The processes of the creation period, on the other hand, were processes of

innovation and *integration* (emphasis his).

How does "very good" apply to the solar system, as God first created it? What purposes can we infer from both biblical and from scientific considerations, that would apply to the solar system? First of all we have from scripture the significant Old Testament verse of Isaiah 45:18,

> For this is what the LORD says—he who created the heavens, he is God; he who fashioned and made the earth, he founded it; he did not create it to be empty, but formed it to be inhabited … (Barker, NIV).

This verse makes the point that earth is special in being designed for life. Scientific observations of other planets and of moons, asteroids, comets, and even extrasolar planets all suggest that planet earth is at least very rare, and possibly unique, in being suited for life. The basic purpose we can infer from this for solar system objects other than earth is that God designed the solar system with stability in order to preserve life on earth. Henry M. Morris refers to the initially good quality of creation in the following,

> There could have been nothing that was *not* good in all creation: no struggle for existence, no disease, no pollution, no physical calamities (earthquakes, floods, etc.) no imbalance or lack of harmony, no disorder, no sin and, above all, *no death*! (emphasis his)

It is important to note that physical events on solar system bodies in some cases could affect earth and create dangers to human beings. Conceivable examples could include instabilities in the sun, collisions of planets or moons, chaotic orbits (of asteroids or comets for example), or unstable orbits (of moons, asteroids, or comets). From a biblical perspective, no process in the solar system would have endangered earth from how objects were initially created. Thus it is the author's perspective that the solar system was essentially stable as it was initially created. However, it is possible this changed after mankind's Fall. Stable in this context does not mean that God's created order would not change. But a tendency toward catastrophism and instability developed after the Creation week. This is not to mean that a major catastrophe in the solar system took place at the time of the Fall. But, processes could have begun then that caused other events later.

God's initial created order in our solar system was stable but not static. After God's supernatural activity during the Creation week, natural processes would determine how solar system bodies would change from that time forward. It is possible that processes could have been set in motion during the Creation week that led to geological events later in the period prior to the Flood or at the time of the Flood. The RATE research project sponsored by the Institute for Creation Research and the Creation Research Society has proposed that a period of accelerated radioactive decay took place during the Creation week, especially on the third day (Snelling, pp. 397–398). In the author's perspective, this is a legitimate possibility so long as it does not endanger life on earth from the associated radiation. If the accelerated decay only took place for a few days during the Creation week and the radioactive minerals were mostly deeply buried or deep in earth's mantle this may be no threat to life. If accelerated radioactive decay is a possibility for earth, it should be considered in relation to solar system bodies as well. Such accelerated decay could serve the purpose of being the energy source to drive geological processes throughout the solar system.

God acted supernaturally and created with purpose in the Creation week. This leads to some of the orderly patterns in the solar system. Of these are the facts that all the planets' orbits are nearly circular and in approximately the same plane, with Mercury having a more elliptical orbit than the others. Pluto, which is now considered a dwarf planet, also has a somewhat elliptical orbit. This makes collisions between planets less likely. Another orderly pattern is the general density trend from Mercury to Jupiter that planets near the sun have a higher density and planets farther from the sun have a lower density. Rather than being a consequence of temperature and an assumed process of materials condensing out of the protosolar nebula, this may be intelligent design done for the purpose of stability. But, this pattern does not exist everywhere in the solar system. For example, the densities of the outer planets increase from 0.71 g/cm^3 at Saturn to 1.67 g/cm^3 at Neptune (Baugher, 1985, p. 417). A similar issue sometimes exists for the density of moons in relation to their distance from the planet, the moons of Saturn being an example (Spencer, 1992, p. 163). The author would take this to mean that stability was not the only purpose of the Creator. It is possible that this could be an intelligent arrangement specifically designed to counter the naturalistic concepts accepted today assuming condensation from a nebula. We do not know all the purposes of the Creator in how things were made. However, we can infer certain purposes such as the priority of making a stable environment for life on earth and the principle of displaying God's greatness and creativity in the way things are made (Romans 1:20). Created uniqueness is also an important concept in a biblical view of the Creator. As we find out more about the planets, moons, and small bodies in our solar system, we find that each have their own unique characteristics and history.

Solar system objects have not remained unchanged since creation. Internal changes in solar system bodies could include chemical processes, outgassing from planet or moon interiors, tectonic and volcanic processes, atmospheric processes, and orbital interactions of moons or small solar system bodies. Impacts have caused dramatic effects on the surfaces of bodies in our solar system. All these are types of processes that would change what God first created. At least some of them may be caused by processes unrelated to judgement. The author would argue that the universe and solar system we find ourselves in are not intended to last forever as they are now, since scripture states that in the future there will be a new heaven and a new earth (see Isaiah 13:10, Isaiah 34:4, Revelation 21:1). The issue of impacts and cratering may be raised at this point. Could there be cratering during the Creation week and between Creation and the Flood? Two possible approaches to this will be addressed below.

Did the Fall of mankind into sin affect solar system bodies? In Genesis 3:17 (Barker, NIV) God speaks to Adam after his sin, saying "Cursed is the ground because of you ...." This seems to imply that this curse affects matter, though its primary consequence for Adam was in how it affected life and Adam's survival. Then in Romans 8:21–22 (Barker, NIV) it describes the creation being under a "bondage to decay." There has not been a clear consensus among creationists on what this means. Some take this to mean that the Second Law of Thermodynamics began at the Fall and is referred to in the expression "bondage to decay." However today there are well qualified creationists who do not agree that the Second Law began at the Fall. Some type of change in Thermodynamics may have occurred at the Fall but the author feels we do not know what that change was. Thus there is a need to research alternatives on this point. It is possible that Thermodynamic effects from the time of the Fall could have significance in modeling chemical and thermal processes in planets or moons for example. However, we should avoid making too many assumptions about certain processes being related to the Fall. Christians sometimes assume that processes like radioactive decay, impacts, chaotic dynamics, and geologic events have to do with the Fall. These processes may change what God created but this does not necessarily make them related to judgment. The Creator may have had good purposes for these processes that have nothing to do with judgment.

Accepted ideas on the origin of the solar system hold that everything in the solar system formed from a common source, which was the protosolar nebula. This nebula was hot plasma mixed with dust and its temperature as it cooled determined the formation of gases, solid minerals, and icy bodies in the solar system. Nearer to the sun, volatile compounds and gases tended to boil away and escape into space (depending on the temperature and gravity). Thus higher density materials were left in the inner solar system and lower boiling point materials were found in the outer solar system. This principle is taken as the explanation for the rocky planets being nearer to the sun and the less dense planets being farther from the sun. Water ice could form at a minimum distance of about 5 astronomical units from the sun. The formation of planets and moons in this scenario depends greatly on the process known as gravitational accretion. Accretion begins as small objects collide at speeds that allow them to partially melt and stick together. These objects gradually get larger and larger as more objects stick together. Eventually the self gravity would tend to make the object partially melt. It is also believed that radioactive decay early on would generate heat that would help melt the rocky planets after they accrete. In order for the interiors of the planets (and large moons) to differentiate into layers with a central core, a mantle, lithosphere, and crust, they must largely melt. While the rocky planets and moons were still partly molten it is believed there were many small bodies throughout the solar system left over from the accretion process. These small bodies became impactors that struck planets and moons. The asteroids are viewed as leftovers from this process and their location in relative proximity to Jupiter allegedly prevented them from accreting into a larger body.

Before addressing the history of our moon we must consider the accepted old age view of the history of the lunar surface. Table 1 summarizes this history from a uniformitarian old age viewpoint, as accepted today by most lunar scientists. There is much renewed interest in lunar research today. After the moon's initial formation and accretion, it is believed the surface of the moon was largely molten for a period of time while impacts occurred from objects left over from the planet formation process. Many writers speak of the "global magma ocean" that is believed to have existed on the moon in its early history. After the surface and crust cooled and solidified, then the surface was capable of preserving evidence of impacts. The oldest impacts include basins such as Aitken and Procellarum which would be estimated to date from about 4.2 Ga (billion years before present). The period from 4.2 to 3.85 Ga is known as the Heavy Bombardment. This is somewhat arbitrarily divided up into Early-Heavy and Late-Heavy. The Late-Heavy Bombardment ended with the last of the large basin impacts such as Imbrium and Orientale. Other smaller impacts occurred throughout all the Heavy Bombardment and continued in decreasing frequency after the large impacts ended. The Early-Heavy and Late-Heavy periods are loosely defined and there are two different views of how this bombardment took place. This impact bombardment is usually viewed as one long event common to all the inner solar system from Mercury to Mars. Some would see it as affecting

Table 1. Uniformitarian history of the lunar surface.

Uniformitarian Age	Event	Comments	Source
1.0 GA	Copernicus impact		P. Moore, G. Hunt, I. Nicolson & P. Cattermole, 1990, p. 155.
2.0 GA	Youngest basalts in Mare Imbrium form	Archean period	J. Head & L. Wilson, 1992, p. 2158.
3.85 GA	Last of major impacts, Imbrium & Orientale (became mare) maria volcanism	End of Hadean period	S. R. Taylor, 1992, p. 155, also P. Moore, G. Hunt, I. Nicolson & P. Cattermole, 1990, p. 154.
3.92 GA	Late-Heavy Bombardment. Nectaris basin impact (became mare)	Cryptomare and Dark Halo volcanism (?) Lunar swirls (?)	J. Head, & L. Wilson, 1992, p 2169.
4.2 GA	Early-Heavy Bombardment; Procellarum and Tranquilitatis Impact basins		S. R. Taylor, 1992, p. 171.
4.35 GA	Lunar "magma ocean" solidifies		S. R. Taylor, 1992, p. 171.
4.5 GA		Beginning of Hadean period	
4.44 GA	Original Highland rocks crystalize		S. R. Taylor, 1992, p. 171.
4.6 GA	Lunar accretion stops, internal differentiation begins		

the entire solar system. Some scientists would see this bombardment as very heavy early on but that it would follow a roughly continuous exponential decline to the present. Others would argue for a less intense impact flux early on, such as around 4.2 to 4.0 Ga ago, then after a more gradual decline there was an intense spike or burst of impacts that took place from about 4.1 to 3.8 Ga. This late spike is referred to as the Lunar Cataclysm (Taylor, 1992, p. 173). There is still significant debate among lunar scientists as to whether there is evidence for this late spike in impacts (Baldwin, 2006; McEwen, Moore, & Shoemaker, 1997, pp. 9239–9240).

There is also evidence for much volcanism on the moon, with basalts of a variety of compositions. Lunar scientists believe that a period of intense volcanism began during the Heavy Bombardment and continued for some time after most of the impacts had ended. This volcanism caused many large craters to fill with lava. The large smooth flat dark colored plains are the mare. The lunar terrain can be loosely divided between the mare and the highlands. The lunar highlands are light colored and are composed almost completely of anorthositic breccia, with some areas indicating a mixture of impact breccia and darker basalts. There are also sites that show a complex sequence of multiple lava flows and multiple impacts. There are apparently some sites where older mare were covered by later high albedo impact breccia. These sites are known as the cryptomare and they are the subject of research interest today. So much of the lunar surface has been brecciated by impacts that virtually none of the original surface remains. The only indications of an original surface before the bombardment would be in fragments found in the highland breccias. The moon has a few shield volcanoes but they are small (compared to some similar volcanoes on earth) and few in number (Head & Wilson, 1992, p. 2160). Volcanism has apparently proceeded primarily out of faults, rilles, and dikes. Most mountains on the moon are composed of highland breccia located around impact basins and were clearly pushed up in impact crater formation. The near side of the moon has many mare structures whereas the far side has only a few of limited extent. This seems to be mainly because the lunar crust is thinner on the near side compared to the far side. The large impacts would have been capable of excavating material down to the lower crust and upper lithosphere in some cases. Thus the impacts provided channels for lavas to reach the surface and the crater basins tended to be where the lava would accumulate. The exact relationship between the impacts and lunar volcanism is still debated today. It is believed that early in the moon's history heat from radioactive decay was significant in helping generate melted pockets of magma in the lunar mantle that built up and was forced to the surface through dikes. Some of the basalts, common in the mare, are of a special composition that possesses high concentrations of potassium, rare earth metals, and phosphorus. These basalts are known as KREEP basalts; which are believed to be a mixture of materials that has undergone partial melting that has concentrated certain elements.

Interpreting Scientific Observations from a Biblical Perspective

When God created planets and moons in our solar system, during the Creation week, what were their initial conditions? Scripture does not answer this type of question. However, we have the statement that the heavens and the earth were completed and we have the important biblical implication that Creation was only approximately 6,000 years ago. The author would assume that creation being completed means that after the Creation week, God no longer created from nothing things that had not existed. Formation of existing matter into various forms would take place by natural processes after the Creation week. This is not to imply that God could not do miracles after the Creation week, but this seems to be a logical assumption for the sake of understanding the science related to what God created. The young age assumption of 6,000 years represents a significant constraint for creationist scientists that may determine much about what processes are realistic options to invoke in our models. During the Creation week, miraculous processes could have been at work but the author prefers not to invoke miracles after the Creation week to explain scientific observations. As Christians, it is a legitimate option for creationists to invoke a miracle, or in some cases to simply say, "God just did it that way." It is not an intellectual copout to invoke a miracle, as long as all the facts have been adequately examined. But in the present state of creationist science, the need is to deal with all the scientific data available.

Let us consider more regarding how the composition of objects may have been initially created in the Creation week. As creationists we do not have to view all objects in the solar system as coming from one common source nebula. This actually gives us greater freedom than uniformitarian scientists in explaining composition differences between objects since it is not necessary to explain how all the variations in composition could come about in the protosolar nebula. The initial primordial conditions could become the key to answering many questions, rather than focusing on the process of formation from accretion or condensation from a nebula. Thus, some planets or moons could have unique features that do not have to be explained as having come about by natural processes from the protosolar nebula. Created uniqueness thus ceases to be a "problem" and becomes a positive that suggests the Creator's handiwork. Also, as creationists we do not need to invoke elements coming into the solar system from supernova explosions to explain unique compositions in small objects such as asteroids, comets, or meteorites. There may not have been adequate time for elements to cross space to reach our solar system from distant supernovae.

On the other hand, to do good science we must resist using "God just did it that way" to explain too many things. It may be possible for example that God created some moons in an initially melted state and they were allowed to solidify by natural radiation processes. This would actually be similar to what planetary scientists say today regarding their formation, for some objects. However, this would probably not be a realistic option for a large rocky planet because of the time that would be required for the body to cool. However, for small icy bodies it could be a realistic option. To suppose the inner planets were created molten, for example, would create difficulties explaining many things in planetary geology because the objects would still not be totally solid today. A long molten state like this would make preservation of craters impossible for instance until the surface solidified.

Cratering

Creationist astronomer Danny Faulkner has suggested there were two periods of impact bombardment in the solar system, one either at Creation or the Fall and another at the Flood (Faulkner, 1999). In his approach, there was a process of accretion that formed the planets but it was a supernaturally accelerated process during the Creation week (Faulkner, 2000, p. 48). The impact bombardment that took place during the Flood is seen by Faulkner as affecting only the earth and its moon and thus it was indeed an aspect of judgment. Faulkner suggested the Flood bombardment could have been caused by comets coming near earth (Faulkner, 1999). However, the impacts that would have happened at Creation or the Fall would be more numerous and would not represent any kind of judgment in Faulkner's view because those impacts did not occur on the earth. The creation or Fall impacts in this scenario would be solar system wide whereas the Flood impacts would be directed only at the earth (Faulkner, 2000, p. 48). This approach is a legitimate option worth considering for the following reasons. First, the bombardment from rapid accretion in the creation week could meet the biblical requirement of a finished creation by the seventh day if it ended by that time. Second, done in this way, the bombardment does not endanger earth. By this approach, it is not necessary to explain all craters from one event surrounding the Flood. Faulkner's approach accepts the concept of accretion but radically shortens the time frame over which it operates. A notable characteristic of this option is that it treats the earth as a kind of special case, so that the earth was not bombarded by the same objects as the rest of the solar system during the early bombardment episode. In Faulkner's approach, the moon could have been included in the early bombardment. During the Flood the earth and moon were struck by many impacts when other objects apparently experienced few impacts. Thus in this scenario, earth was essentially protected from impacts by the Creator, until the opportune time during the life of Noah.

An alternative approach would be the following. First, because the Creation week is more a time of organization and formation of objects, it may be that impacts are inappropriate as a means of creating planets, moons, and other objects. Impacts excluding earth at the time of Creation or the Fall don't seem to have a clear purpose. If these impacts were related to mankind's sin, why would they affect objects other than the earth and not affect earth? Though impacts where no life is present are not a judgment, they can be seen as destructive and as something that tears down some of the order God created. Should volcanism and radioactive decay be considered destructive? The author feels these processes are more neutral and can be either destructive or constructive, whereas impacts are inherently destructive. Therefore volcanism and radioactive decay may be more appropriate in the Creation week than impacts.

Note that this is a philosophical objection to impacts during Creation, not a scientific objection. Scripture seems to emphasize God creating by fiat command, speaking things into existence (see Genesis 1:3, Psalm 33:9). However, this does not rule out the possibility of some enhanced or directed processes during the Creation week. So, if God created solar system bodies by fiat command the accretion process is not necessary, though it may be applicable in some contexts. Rather than assuming planets and moons were created molten or that the accretion process largely melted them, the author would assume that large rocky bodies were created initially solid. Large moons which have a significant portion of their mass as water ice may have been solid as well but it may be that should be considered on a case by case basis. The primary biblical consideration related to the question of whether objects were initially solid or not is the age of the solar system. Rapid supernatural accretion in a few days might require supernatural cooling in order to be a realistic option for explaining surfaces of solar system bodies geologically. It is not clear how this cooling issue would be resolved in Faulkner's approach so that it realistically deals with planetary geology.

Second, the author prefers not to treat earth as a special case in terms of how it was bombarded from space. The author prefers to proceed on the assumption that earth and the moon were struck by the same population of objects that struck Mars and Mercury. This seems to be indicated by crater size-frequency distribution statistics. This is where plots are constructed which graph the cumulative number of craters as a function of crater size (or by impactors size). These plots allow statistical analysis of crater populations of different kinds. Stuart Ross Taylor (1992, p. 160) comments on the crater record on Mercury compared to Mars and the Moon:

> The general conclusion from crater counting studies is that the crater size-frequency distribution is similar to that of Mars or the lunar highlands, but that Mercury is deficient in craters smaller than 50 km.

Taylor above describes the "general similarity" of the cratering history of Mercury, the Moon, and Mars. A certain power law has been used for years as a rough quantitative description of the relationship between number of craters and crater diameter. The number of craters (*N*) of a given size is considered to be roughly proportional to the inverse square of the crater diameter (D^{-2}). Smaller craters usually follow a different distribution. There is a crater size for each cratered body below which the distribution changes form, because of the high number of secondary craters. For some years it was generally believed that if a surface gave a curve close to D^{-3} that meant it was near crater saturation. However it has been realized that this is an oversimplification. For most solar system bodies, crater distribution plots are dominated by secondary craters below some size. Thus for crater statistics on the moon, for example, it is common to omit numbers for craters below 20 or 30 km diameter, though there might be some debate about at what size to "draw the line." The D^{-2} power law is approximately valid for Mars, earth, and the moon according to Grieve and Dence (1979, p. 233). Large lunar crater distributions average between $D^{-1.8}$ to $D^{-2.0}$. Earth craters above about 22 km in diameter follow the D^{-2} power law as well. In addition, if you look at the size-frequency distribution of the Apollo asteroids and rescale their sizes to the size of impacts they would create on the moon, the same D^{-2} power law results (Grieve & Dence, 1979). Thus, this suggests that the craters produced in the entire inner solar system may have been produced by a common population of objects and those impactors were similar in size and velocity characteristics to today's asteroids. Note, on the other hand, that the crater size frequency distributions for moons of the giant planets in the outer solar system are significantly different, possibly suggesting a different impactor population (Woronow, Strom, & Gurnis, 1982, p. 274). The following quote is from Woronow, Strom, and Gurnis. (p. 244), in a discussion of whether the lunar highlands are saturated.

> … the Moon, Mercury, and Mars. While all three bodies do have surprisingly similar crater densities, the complexity of the size-density curves does not comply with the analytical and simulation predictions of simple power-law relationships at saturation.

In Faulkner's approach above a question to ask is why are the crater distributions of Mars, Mercury, the moon, and the earth similar if the earth was bombarded by a different population of objects at a different time?

Internal Geological Processes for the Moon

Our moon can serve as an important case study for considering how to integrate a biblical young age view of history with scientific data. Cratering has determined much about the lunar surface but the moon's own endogenic geophysical processes are also crucial for understanding a history of the moon.

Impacts are an external or exogenic influence on the moon, but a very important endogenic process in the moon has been radioactive decay. There are basalts of a variety of compositions on the moon and there has obviously been massive lava flows on its surface in the past. The lunar mare account for about 17% of the total surface area of the moon (mostly on the near side). One estimate of the average depth of the mare basalts was 400 meters for most areas. However, some local regions have basalts of 1–2 km depth, and some large impact basins may have basalts as much as 6–8 km depth near basin centers. The total volume of mare basalts has been estimated at 10^7 km^3 (Head & Wilson, 1992, p. 2155). Though impacts would fracture the crust and possibly provide channels for lava to reach the surface, radioactive heating seems to be the likely energy source to drive this volcanism. Today, the moon seems to be nearly entirely solid and thus mantle convection is probably not possible. Some scientists have proposed mantle convection in the past but most lunar scientists seem to prefer the transport of magma to the surface being through dikes. In the lunar near side mare, the lava apparently erupted frequently from inside the craters, though in some cases lava flowed into or over basins.

A recent study examined heat-producing radioactive elements in lunar pyroclastic glasses from Apollo 11, 12, 14, and 15 samples (Hagerty, Shearer, & Vaniman, 2006). These pyroclastic glass particles were from KREEP basalts. In this study, radioactive elements measured included thorium, samarium, uranium, and potassium. The most abundant of these in these pyroclastics was potassium (at 212 ppm concentration), followed by thorium and samarium. Thorium concentrations ranged from 0.2 to 5.6 ppm; samarium ranged from 0.87 to 21 ppm. The KREEP pyroclastic glasses are believed to have come from source regions greater than 400 km depth in the moon. This is based on experimental studies of the melting of these lunar glasses. These glasses melt at temperatures in the range of 1410–1560 Celsius and pressures of 1.7–2.5 GPa (Hagerty, Shearer, & Vaniman, 2006, p. 3459). Various researchers have found that there is usually a predictable linear relationship between lunar concentrations of uranium and thorium as well as between potassium and thorium, so that concentrations of U and K are sometimes estimated from thorium measurements. In the uniformitarian understanding of the moon, it is believed that most of the mare filled from volcanic fire fountains and other lava eruptions roughly from 3.8 to 3.0 Ga. Thus at that time, there would be significant heat at a variety of depths in the lunar mantle, at least in zones if not the entire mantle, which would generate the magma that would make its way to the surface, filling the large impact basins.

Toward a Geologic History of the Moon

The moon's history may have begun with it created solid and already differentiated. This avoids an age issue with the cooling of the lunar crust and also means that the moon had a surface that was initially stronger than if it initially was covered with a magma ocean. This may help explain observations to follow about the South Polar Aitken basin. Periods of accelerated radioactive decay at creation and the Flood would both have generated large amounts of heat that may have melted significant portions of the mantle. It is possible a period of volcanism could have followed the accelerated radioactive decay at creation though there may be little tangible evidence of this left on the surface. The original surface of the moon has been completely reworked by impacts and volcanism. It seems clear that if many of the lunar craters date to the time of the Flood, lunar volcanism (mare filling) dates from late in the Flood and into the post-Flood period. The lunar highlands are older than the mare and have not been covered by basalt eruptions, though there are sites where mare basalts and highland breccias mix. The lunar highlands in general have over 30 times the crater density (number of craters in a given surface area) as the lunar mare (Taylor, 1992, p. 157). The highlands are composed mainly of breccia containing two rock types, anorthositic gabbro rich in pyroxene and the KREEP basalts. Highland rocks have less silicates than earth granites for example but more iron oxide, aluminum oxide, titanium dioxide, and calcium oxide (Moore, Hunt, Nicolson, & Cattermole, 1990, pp. 158–159).

In the naturalistic view of the moon's history, the Heavy Bombardment is believed to have lasted about 700 million years (Moore et al., 1990, p. 154). The relative age sequence accepted today for some of the major impact basins would begin with Tranquillitatis, followed by Fecunditatis, Nubium, Serenitatis, Nectaris, Humorum, Crisium, Imbrium, and Orientale. These are all on the moon's near side. Sometimes Procellarum might be mentioned as another large basin, possibly one of the oldest and largest (over 3000 km in diameter). However there is not complete agreement whether it is an impact basin. It could be viewed as a large lava plain. Procellarum is a region that the Imbrium basin is found within. Imbrium is 1160 km in diameter, with an inner ring of about 670 km diameter (Taylor, 1992, p. 163). Many of the lunar samples collected by the Apollo missions were taken from various sites in and around the Imbrium and Serenitatis basins. Radioactive dates for lunar samples believed to be Imbrium ejecta range from 3.85 to 3.95 billion years (Taylor, 1992, p. 166).

Lunar scientists believe that the mare volcanism started before Heavy Bombardment had ended and continued for approximately 700 million years (Moore et. al., 1990, p. 154). The lunar mare basalts are somewhat similar to the lavas that erupt on earth's mid-ocean ridges but with much greater amounts of iron, magnesium, and titanium. The loose rock and soil common in the mare includes many small glass particles. The Apollo 17 mission collected samples of an orange colored soil made up of very small glass particles. It has been suggested these particles imply an impact happened in molten lava (Moore et al., 1990, p. 154). There is also evidence from Apollo 15 samples that some impacts may have taken place in a molten surface (Ryder, 1988). Graham Ryder (Ryder, 1988, p. 751) describes these samples as containing a yellow glass from near the Apennine Mountains, located near the eastern edge of the Imbrium basin.

> Several of them contain yellow residual glasses which cross-cut the crystallized phases; some show more extreme disruption. The features of the glasses appear to be compatible only with impact disruption, ejection and quenching from actively crystallizing flows, indicating a high impact flux immediately after the impact that formed the Imbrium basin.

This could explain how there could be large impacts followed by volcanism followed by smaller impacts, all in a short timescale. However, it is not clear how widespread evidence for impacts in a molten surface is on the moon.

This could be relevant to ghost craters, which are very common in the mare regions. Faulkner has written about how ghost craters argue for a short time scale between impacts and lunar volcanism (Faulkner, 1998, pp. 208–209). Though ghost craters are usually believed to have been overflowed with lava after the crater formed, another possibility is that in some areas smaller impacts actually occurred while the surface was still molten. Thus a large impact such as Imbrium might be followed by massive lava eruptions. While the lava is still molten smaller impacts occur. A crater that formed in molten material would have a less pronounced rim and would not be as deep, as many ghost craters appear today. Also, the reduction in volume of the lava as it cooled would tend to form a depression inside a filled crater. The appearance of a ghost crater formed this way might be indistinguishable from a ghost crater that was overflowed by lava. This was considered in the early years of lunar research but it was not considered likely that impacts would happen while surfaces were still covered with molten material (Cruikshank, Hartmann, & Wood, 1973, p. 450). In a young age view, this could explain how some lunar surface features could be "collapsed" into a very brief time frame.

The Aitken Basin

The South Pole Aitken (or SPA) impact basin is an important structure on the moon's surface and is likely the largest impact structure in the solar system. It is also a structure with some mysterious characteristics that are the subject of much debate today among lunar scientists. The Aitken basin is a very large circular depression on the far side, whose center is at approximately 50° south lunar latitude. Aitken is approximately 2500 km in diameter and 12 km deep. Inside the SPA are a number of smaller impact craters. In 1994 the Clementine mission collected high resolution multispectral data on the moon's surface, from its ultraviolet, visible, and near-infrared cameras (Robinson & Riner, 2005). The surface within the SPA basin was found by Clementine data to be of unique composition different from both the lunar highlands and the mare. Iron oxide (FeO) and TiO_2 have been of particular interest in studies mapping minerals on the lunar surface. The SPA basin is particularly abundant in FeO. It was expected that there would be large amounts of olivine present in SPA but this is not the case. Olivine is abundant in earth's mantle and is suspected to be significant in the moon's mantle as well. Instead, the floor of the Aitken basin is abundant in iron and pyroxenes (Robinson & Riner, 2005, p. 673). This is surprising because of the size of the Aitken crater. By applying crater scaling physics, the Aitken crater should excavate to a depth of 100 to 150 km. This would reach into the lunar mantle. Thus there has been significant debate over why the Aitken basin did not fill with lava from the mantle. There are some small patches of mare fill in some of the craters found within Aitken, but Aitken itself did not fill with lava as many large craters on the near side did.

The reason for this appears to be three-fold. First the lunar crust is significantly thicker on the far side. In the floor of the SPA the crust is believed to be only about 20 km thick but outside SPA on the far side the average thickness would be 68 km (Lucey, Taylor, & Hawke, 1998, pp. 3706). Thickness of the crust reaches 100 km in some areas. The near side crust is approximately 50–60 km thick. Thus, it is generally believed that volcanic dikes did not penetrate all the way to the surface on the far side, but were able to reach the surface on the near side, after many of the large lunar impacts. The age of the Aitken basin is something that lunar scientists seem to not have arrived at a consensus on. There are few estimates of its age because no lunar samples have been collected from the Aitken region and dated radiometrically. Because the rim of Aitken is heavily eroded, probably by impact ejecta, and because of the many other craters on top of it, it appears to be an early impact. However, one estimate puts it at 3.8 billion years, which would be about the same time as the imbrium impact on the near side (Walker & El-Baz, 1982). In the accepted old age history of the moon the lunar magma ocean solidified at about 4.3 billion years. Thus the Aitken impact would have been a few hundred million years after the surface became solid. Such a large impact would have easily exposed mantle material and brought lava to the surface because the moon had been covered in a few hundred kilometers of molten material. But the real mineralogical evidence from Clementine remote sensing data suggests the surface of the moon was quite rigid and solid when the Aitken impact occurred. Thus the author believes this suggests the moon was created solid. This is the second reason for Aitken lacking a large mantle plug filling it with lava; the surface was initially very rigid. However after Aitken and other large impacts and possible accelerated radioactive decay, volcanism could ensue after the Aitken crater had settled to its final state. But the volcanism affected the near side more than the far side because of the difference in crustal thickness.

Another possible reason for the limited depth of SPA has been proposed (Lucey, Taylor, & Hawke, 1998, p. 3706), that the impact took place at a low angle of incidence. Thus the Aitken impact, if it were a "glancing blow" on the moon, would not penetrate as deeply into the interior. Considering the geometry of the moon's orbit and tilt in relation to the ecliptic, this is possible. An object from near the ecliptic plane (such as from the asteroid belt) could strike a low angle impact near the South Pole if the moon were just above the ecliptic at the time. This could explain why the depth of the Aitken basin is only about 12 km instead of over 100 km.

Lunar Magnetism and Lunar Mysteries

Today the moon possesses only a very weak magnetic field. However, because some lunar samples have been found to have remnant magnetization, most lunar scientists believe the moon once possessed a stronger dipole field. From the old age naturalistic perspective, this assumes the moon would have been capable in the past of sustaining a lunar dynamo. A dynamo is generally thought to be impossible today because the amount of molten material believed to be in the lunar core and mantle is limited. However, in addition to some magnetized lunar samples, there are regions on the moon that have measurable positive magnetic anomalies. The magnetic data from the moon provide a means for creationists to infer the approximate age of the Imbrium impact.

In 1984, Dr. D. Russell Humphreys published a paper on the creation of planetary magnetic fields (Humphreys, 1984). In this paper Humphreys details his model for how magnetic fields of various solar system bodies could have been created. The model involves God creating bodies initially made of water. The protons in the hydrogen atoms would have been created with their spins aligned initially, then the water is supernaturally transformed into other materials, such as iron for the lunar core. Humphreys calculated the initial magnetic moment that would result from this for eleven solar system bodies including the moon. This model of magnetic fields has been confirmed as giving plausible magnetic moment magnitudes for Earth, Uranus, and Neptune. Humphreys' model is unlike the evolutionary dynamo model in that it does not require that the core of a body be liquid. Humphreys' model also can be applied to smaller bodies such as moons where often dynamo models cannot work. Humphreys referred to remnant magnetic measurements from two lunar samples, one of which is sample number 15498 (breccia), collected by the Apollo 15 astronauts from a crater called Dune near the Appenine mountains (Runcorn, 1983). This sample is near the outer rim of the Imbrium basin. Humphreys calculates that the decay time of the Moon's dipole field would have been approximately 364 years. The initial magnetic field of the moon, by Humphreys' model would decay rapidly. The 15498 breccia sample measurements indicate the ambient field at the time the breccia cooled would have been 2100 nanotesla (0.021 Gauss). This would imply a lunar magnetic moment of about 1.1×10^{20} J/T. Humphreys calculates a magnetic moment at creation of 1.7×10^{22} J/T. This implies that the 15498 sample would have cooled below the Curie temperature about 1,840 years after creation. Humphreys takes this as an upper limit figure. This would put the Imbrium impact occurring approximately 183 years after the Flood. This would imply that impacts may have happened on earth for some time in the post-Flood period. There is evidence of impacts on earth after the Flood. An earth impact data set from 1998 from geologist Richard Grieve has 43 craters listed as Cenozoic and later in uniformitarian age (Spencer, 1999, pp. 163–165). Creationists Froede and Williams also examined the Wetumpka crater remnant in Alabama and argued it was a post-Flood impact (Froede & Williams, 1999).

If Humphreys' magnetic model is correct for the moon, this implies that the Imbrium impact coincided roughly with the early part of the post-Flood ice age (Oard, 1990, p. 117). There were clearly a number of small impacts after Imbrium, evidenced by the many smaller craters, including ghost craters in and around the Imbrium basin region. Imbrium is clearly one of the latter of the large impacts judging from the relative stratigraphic position of the various craters and lava flows on the moon. Thus, a date of 1,840 years after creation for the Imbrium impact implies virtually all the large impacts on the moon we see today took place during Noah's Flood. The post-Imbrium lava flows that filled the crater structure would then also coincide roughly with earth's post-Flood ice age. The "heavy bombardment" in the old age timescale is a relatively brief period of only about 700 million years. Since all the lunar samples available are from in and around the Imbrium basin, we have no radioactive dates from other impact craters, unless one could argue exceptions from particular samples. The large impacts on the moon scattered ejecta over wide areas so that the ejecta of multiple impacts is often mixed together, making it difficult to be sure in some cases which impact a sample comes from. Also, some lunar samples possessed only a very weak magnetic signature and could not be reliably measured. Thus there is limited magnetic data available from lunar samples.

A potential test of Humphreys' magnetic moment calculation could come from something that remains a lunar mystery of great interest to lunar scientists today, the lunar swirls. Lunar swirls are high albedo surface materials in certain regions on the moon. They look much brighter than the surrounding surface material, which is usually dark colored mare basalts (see Figure 1). The swirls are known to not be topographical features and are generally in very flat areas. Swirls have an irregular swirling shape, sometimes with darker swirling areas within them and they are all located in regions of a positive magnetic anomaly. Most of the swirls known are located in regions antipodal to large impact structures (such as Imbrium and Orientale), though one significant exception to this is the Reiner-Gamma formation on the near side of the Moon (Hood & Williams, 1989, pp. 99–100, 112). Reiner-Gamma is located in the Procellarum region (57.8°W, 8.1°N); it covers an area roughly 30 km by 60 km. There have been various hypotheses on what makes these swirl patterns. Clementine mission data have made clear that the swirl material is not of different composition than the surrounding surface (Blewett, Hawke, & Lucey, 2005). This tends to argue against one hypothesis which is that during recent comet impacts, the comet coma would deposit surface material. Those arguing for comet impacts forming the swirls would date the swirls as a recent phenomena having to do with interactions between the vapor in a comet coma and earth's magnetosphere. If comet impacts were the source of the swirls however, why would the swirls be associated with magnetic anomalies and large craters antipodal to them? The question is not totally resolved and the lunar swirls are undoubtedly going to be the subject of future lunar research. Today lunar scientists seem to lean toward applying various aspects of what is called space weathering to explain the swirls.

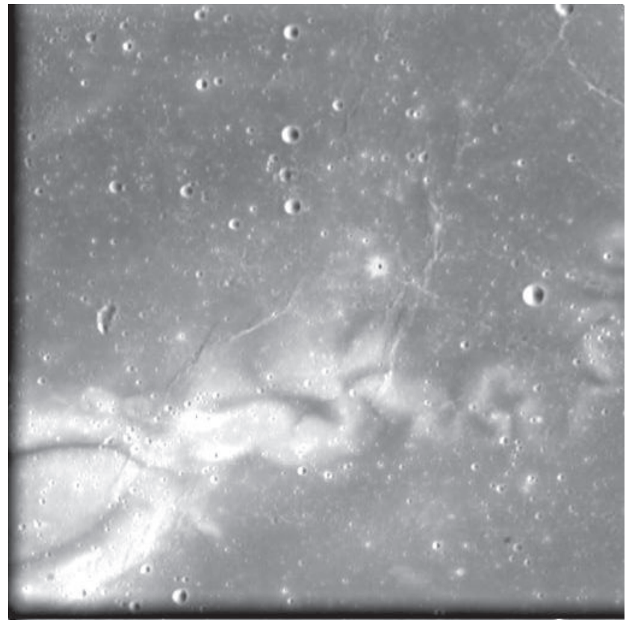

Figure 1. Reiner-Gamma swirl site photo.

Space weathering is a term that refers to several phenomena that can gradually change the appearance and color of minerals exposed to space. First, micrometeorites erode rock surfaces and expose "fresher" rock. Second, solar wind ions and protons continually bombard the lunar surface and these particles are believed to tend to darken the surface over time via a process of chemical reduction. The solar wind also causes sputtering erosion of the surface. Third, cosmic rays also bombard minerals on the lunar surface and these may also change the appearance of exposed rock. These processes are believed to generally redden and darken appearance of lunar rock over time. One of the explanations of the swirls that has been put forward is that the presence of positive magnetic anomalies in regions like Reiner-Gamma could deflect solar wind ions and tend to shield the surface minerals from the darkening effect of the radiation. One study did simulations of solar wind bombardment with various magnetic field strengths and found that a field intensity of about 1000 nanotesla is sufficient to cause deflection of ions over distances up to 30 km. Note that the field intensity implied from the measurements of sample 15498 was more than twice this figure. On the other hand, the current magnetic anomaly at the Reiner-Gamma swirl area is only about 7 nanotesla (Blewett, Hughes, Hawke, & Richmond, 2007). This implies that today there is little deflection of solar wind ions around the Reiner-Gamma structure, but there may have been more in the past when the moon's dipole field was more intense.

Thus a plausible young-age creation interpretation of the lunar swirls could be the following. The moon was created with a magnetic field that decayed exponentially over a period of approximately 1,800 or 2,000 years. Radioactive heating in the moon's interior may have contributed to magnetic anomalies by being a driving force that generated pressure forcing magnetic minerals toward the surface (including iron and samarium for example). It seems some impacts are connected with magnetic anomalies as well. It is likely that shock waves and seismic reflections tended to concentrate denser minerals at antipodal points to large craters. Reiner-Gamma is apparently not associated with any large crater antipodal to it. So it is possible magnetic shielding of the solar wind may not be the only mechanism for forming the swirls. But, it is plausible that magnetic anomalies could be enhanced at approximately the time of the Flood if there were a period of accelerated radioactive decay at that time, coupled with frequent impacts.

This provides a better explanation for lunar volcanism than the uniformitarian approach to lunar history. In the uniformitarian view, there is no clear cause of the volcanism that fills the large mare basins. Large impacts do not really drive volcanism (Glikson, 2003), they could however create deep fractures and thin the crust in a large crater. This could make it easier for lava to reach the surface. The Imbrium impact, one of the latter of the large lunar impacts, occurred approximately 180 years after Noah's Flood and that was probably immediately followed by massive lava flows that formed the Imbrium maria. At that time the moon's dipole field was stronger than today and it is plausible for the magnetic anomaly at Reiner-Gamma to have been more pronounced than today. From the old age perspective, the swirls are an enigma. Their bright whitish appearance makes them look young. Lunar scientists describe them as "immature," meaning they have not been weathered extensively by the solar wind. But their association with positive magnetic anomalies implies the swirls would have originated approximately 4.0 to 3.8 billion years ago, while the moon had a lunar dynamo. In any conceivable scenario for a lunar dynamo, it could not last long. A lunar dynamo would have to last a minimum of several hundred million years to explain the swirls. But even if a lunar dynamo were possible, the dynamo has long since stopped and so the Reiner-Gamma formation for instance has been exposed to the solar wind for probably over 3 billion years since the lunar dynamo would have stopped. Thus, if you view the swirls as about 4 billion years in age, why are they still so white? The solution is to see the entire moon as young, that the lunar magnetic field underwent free decay rather than being a dynamo, and that there were impacts and volcanism on the moon surrounding the Noahic Flood that continued into the post-Flood period. Thus in the above scenario, most of what we see on the moon's surface would date from approximately the time of Noah's Flood and the post-Flood ice age.

Considering Imbrium and the lunar maria, a question often arises regarding why are there more large impact basins on the near side of the moon versus the far side? The answer to this question is not clear. Since the Clementine mission to the moon there has been a renewed research interest in examining cratering asymmetries on the moon's surface in the light of dynamics considerations. A common answer often given for there being more large impact basins on the near side is that the thinner near side crust allows lava to reach the surface easier after impacts, thus craters are covered and the maria regions are younger. This argument essentially implies that if the far side of the moon had a thinner crust, the two hemispheres of the moon would look more alike because both sides have been similarly cratered. But the thinner near side crust only really explains why the large impact basins would fill with lava, not why they exist or why there would be more of them on the moon's near side.

Recent studies have shown that the moon possesses an asymmetrical crater distribution related to its orbital motion (something common for other moons in the solar system). The leading hemisphere of a moon tends to be more densely cratered than the trailing hemisphere. Statistical studies show that the density of craters (of approximately 5 to 10 km diameter) on the leading or apex side of the moon is 1.5 times more than the density on the trailing side (Morota & Furumoto, 2003). Studies of this kind can only look at the statistics of relatively young small craters because of how lunar volcanism complicates counting larger craters and because the asymmetry effect is less for larger impactors. Thus this leading/trailing asymmetry does not explain the distribution of the large impact basins. Similar statistical and theoretical studies regarding the near side versus the far side of the moon show no significant difference (again for small recent craters). The difference between the near and far sides of the moon thus is essentially only significant for a relatively small number of very large impact structures. The leading/trailing asymmetry has allowed estimates to be made of the average velocity of the lunar impactors. The speed of the impactors is estimated to have been in the range of 10 to 15 km/s. This speed would be consistent with near earth objects, but would not be plausible for comets. This may give some clues that could guide further research regarding the source of the impacts. If impacts were still occurring on earth and the moon over 150 years after the Flood, creationists should examine dynamics scenarios that would put objects in earth crossing orbits for a period of 100 to 200 years, rather than only looking at brief scenarios such as if the impact bombardment ended with the Flood year for instance. The volcanism and geology of the lunar surface may give additional clues regarding what time frames are plausible for the length of the impact bombardment. Thus, for the large impacts on the moon to happen in a period of two weeks from a cluster of objects close together for instance could be logical for explaining the distribution of large impact basins on the moon, but it may be implausible for explaining the geology of the surface.

What about the question of an impact bombardment at the time of creation or the Fall? Considering all the above evidence about lunar cratering and volcanism, is there anything that could be evidence for impacts during the Creation week? There are mysterious structures in the lunar highlands that are known as dark halo craters and other similar structures that are called cryptomare. These are regions where apparently dark mare-like material was covered by lighter colored highland breccias. Dark halo craters have multiple means of formation, some of which are volcanic. Cryptomare is a term for ancient mare buried by lighter highland material. First of all, some of the dark halo structures are clearly of volcanic origin. These structures are often not circular, they are often aligned near linear rilles or fractures, and they lack crater rays like some impact craters. They also tend to not have a clearly defined raised rim (Hawke & Bell, 1981). Many of these are likely sources of pyroclastic eruptions. A recent study of dark halo and cryptomare structures based on Clementine data was done in the region near two craters called Lomonosov (93 km, 27.5 °N, 98°E) and Fleming (130 km, 15°N, 109.5°E). These craters are too far east to be in view from earth. In the Lomonosov-Fleming region 17 dark halo craters were studied and all were concluded to be of impact origin, not volcanic (Giguere et al., 2003).

There are many different ways a dark material could be mixed with or covered by lighter material from impact ejecta. The dark material could be part of the impact melt from the impact, rather than from a prior impact. Or, there could have been an earlier impact crater that filled with lava that was subsequently covered by lighter highland type material. It is also possible that the mare that was covered actually did not fill an ancient crater but was just a lava plain. It is necessary to analyze the composition and what is called the maturity of the material. This assesses the degree of "darkening" of the minerals from exposure to solar radiation in relation to its composition to determine what processes were at work in the formation of a certain surface region. In the Lomonosov-Fleming region it was concluded that early mare had been excavated by later impacts. In this study the researchers concluded that the earliest cryptomare examined were of "Nectarian" or "pre-Nectarian" age. This would put the maria that were later excavated by impacts as forming in approximately the middle of the heavy bombardment, after the Tranquilitatis and Serenitatis impacts but before Imbrium. If this relative age of these mare is correct these cryptomare are just the beginning of the mare basalt eruptions. Thus they may not be ancient enough to be in a separate earlier event such as during the Creation week. Also, were these early lava eruptions filling crater structures? At the present state of our knowledge using remote sensing data it seems unlikely this can be answered. Future missions to the moon may investigate some of the dark halo and cryptomare formations and provide more insight. Thus to the author, it seems the dark halo and cryptomare point to early basalt eruptions, but these may or may not be related to early impacts. The author would lean toward the cryptomare being early volcanism unrelated to impacts, though this must be a tentative conclusion.

Conclusions

The author has attempted to clarify from some biblical considerations how the solar system was created. On many details there is room for multiple interpretations of the facts because of details scripture does not address and because of the limitations of the scientific evidence we have available. Several guidelines are found in the Genesis account of the Creation week and other scriptures that allude to the Creation account. First we have the guideline that at the end of the Creation week, the heavens and earth were "completed." This tends to put a constraint on any special processes creationists might propose for the Creation week, it must be finished and not continue after the Creation week. Then there is the guideline that all God created during the Creation week was evaluated as "very good." This must be considered along side the concept of purpose. There is clearly purpose in how earth was created and in how the solar system was made as well. There is a general implication of stability in how our solar system was made that tends to protect life on earth. On the other hand, initial stability as objects were created does not mean that they were intended to be static. Natural processes have changed what God originally created. Some of the changes since Creation could be related to mankind's Fall. However, it is important to be cautious about assuming that various processes are related to the Fall. Not all changes are related to mankind's sin as a judgment. This is important for creationists to understand as we try to progress in a creationist understanding of astronomy. The author's approach to solar system questions has been outlined and compared to that of Dr. Danny Faulkner. Faulkner explains cratering as occurring in two episodes and sees the impacts on the earth and moon during the Flood as being very focused on the earth-moon system. However the author believes the available evidence can be explained in terms of one impact bombardment episode surrounding the time of Noah's Flood. In the author's view, this episode affected at least the entire inner solar system from Mercury to Mars.

To explain the history of planets and moons in our solar system from a young age perspective will require much more research. Some processes assumed by uniformitarian scientists are not necessary in a creationist approach. Thus assuming solid rocky planets and large moons were created solid is preferable to invoking some kind of accretion process. Supernatural activity of God during the Creation week could explain many unique characteristics and compositions of various solar system bodies. The evidence on our Moon points to one significant event of impact cratering, the latter part of which was accompanied by volcanism. It is very difficult to draw any conclusions about the lunar surface prior to the bombardment at the time of the Flood because of how the surface has been modified. The complex sequence of volcanic eruptions and impacts on the moon the author believes is more plausibly understood from a young age perspective as one extended event rather than two or more events. Periods of accelerated radioactive decay during the Creation week and the Flood could provide heat to drive lunar volcanism. Significant solar system events led to impacts on solar system bodies at the time of the Flood judgment on earth. Questions remain regarding what kind of events provide the source of impactors in the solar system. Resolving this question will require more research and a greater understanding of the history of surfaces of solar system bodies. A young age model for magnetic fields from Humphreys suggests the Imbrium impact on the moon was in the post-Flood period. This supports impacts taking place on Earth during and following Noah's Flood (Spencer, 1998). The mysterious lunar swirl formations can be plausibly explained by relating Humphreys' magnetism model to a possible mechanism for swirl formation. The bright appearance of the lunar swirls may also argue for a young moon.

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