Energy of lunar month

How many days made a true month before the Global Flood? How much kinetic energy did the Moon lose to settle into its modern lower (and shorter) orbit? Where did that energy go? That debate has drawn little attention in the lay press. But it forms a small part of a larger debate: did a Global Flood occur at all? What made the “mavericks of the Solar System”? And when did the moon lose its energy?

On May 31, Walter T. Brown of the Center for Scientific Creation revised that part of his Hydroplate Theory that deals with the energy of the month. Today Dr. Brown and I present details on the amount of energy the moon must have lost to drop into its lower orbit. We show the moon lost this energy after several very heavy and fast objects bombarded it. The bombarding objects need not have melted the moon but might have given the moon its present liquid-metal core. And the Bible gives a likely clue to when this happened.

What energy does a body in orbit have?

Sir Isaac Newton worked out how strongly every particle in the universe attracts every other particle. We call this the Law of Gravity:

$$F = \frac{GMm}{R^2}$$

where M and m represent the masses of the primary and the orbiting body, G represents the Newtonian gravitational constant, and R represents the radial distance between the two bodies.

A body in orbit has a certain orbital energy. By convention, investigators treat this as a negative. It represents the energy one would need to break out of an orbit. A body of mass m orbiting a primary of mass M at semimajor axis a (the best average distance between the two bodies) has this much energy:

$$E = -\frac{GMm}{2a}$$

A month is the *period* of a moon, the time to start from one point and come back to the same point. This value is:

$$P = 2\pi\sqrt{\frac{a^3}{GM}}$$

So that:

$$a = \sqrt[3]{\frac{GMP^2}{4\pi^2}}$$

So:

$$E = -m\sqrt[3]{\frac{(\pi G)^2}{2}}\left(\sqrt[3]{M/P}\right)^2$$

and thus:

$$E\alpha\left[\frac{M}{P}\right]^{\frac{2}{3}}$$

How much energy did the moon have to lose?

At least three percent of the earth's mass escaped from the earth during the Flood event. That mass persists as the "mavericks of the Solar System": meteoroids, asteroids, comets, and trans-Neptunian objects.

If none of these objects had bombarded the Moon, the Moon would have coasted to a higher orbit with a longer month. Brown calculates the *synodic* month (the time for the moon to cycle exactly once through its phases) expanded from 30 days to 31.930 days. But today a synodic lunar month has 29.531 days. Furthermore, those days do not last as long as a day lasted before. The ancient Egyptians and Babylonians kept a calendar with a 30-day month and a 360-day year. Today a year has 365.256 days.

So the objects that bombarded the moon, needed to rob it of this much energy to slow it to its modern orbit:

$$\frac{E_b - E_t}{E_b} = \frac{{P_b}^{-\frac{2}{3}} - {P_t}^{-\frac{2}{3}}}{{P_b}^{-\frac{2}{3}}} = \frac{\left(31.93 \times \frac{365.256}{360}\right)^{-\frac{2}{3}} - 29.531^{-\frac{2}{3}}}{\left(31.93 \times \frac{365.256}{360}\right)^{-\frac{2}{3}}}$$

$$= -0.06$$

In other words, the moon lost six percent of its orbital energy in the bombardment that followed the breakout of the subcrustal ocean.

(Critical observers will readily see that *synodic* months differ from *sidereal* months, the time taken for the moon to return to the same alignment with the stars. But in this *first-order approximation*, the difference does not matter.)

Does this energy loss present a heat problem?

Critics of this part of the Hydroplate Theory say the moon couldn't have taken this bombardment without breaking apart.

First, let us calculate an energy budget. To do that, we need the values of G, M, m, and a.

Henry Cavendish measured the gravitational attraction between two objects of known mass at a known distance. From this he calculated G:

$$G = 6.673 \times 10^{-11} \frac{Nm^2}{kg^2} = 6.673 \times 10^{-11} \frac{Jm}{kg^2}$$

In so doing, Cavendish weighed the earth:

$$M = 5.9736 \times 10^2 4kg$$

The moon has 1.23 percent of the mass of the Earth:

$$m = 7.349 \times 10^2 2kg$$

The moon follows a near-circular orbit:

$$a = 3.844 \times 10^8 m$$

Thus:

$$E_t = \frac{6.673 \times 5.936 \times 7.349}{2 \times 3.844} \times 10^{24+22-11-8} = 3.786 \times 10^{28} J$$

The original value was 6.383 percent higher, so the moon lost this much energy:

$$E_b - E_t = 3.786 \times 10^{28} J \times 6.383 \times 10^{-2} = 2.417 \times 10^{27} J$$

Brown proposes the moon lost that amount of orbital energy from bombardment. That much bombardment must have transferred *heat* to the moon, perhaps as much as that 2.417 octillion joules, perhaps more, perhaps less. The efficiency of any particular strike (that is, how much energy went into changing the orbit of the moon instead of wasting as heat) depends on how far the lunar material would compress under that strike. Two octillion four hundred seventeen septillion joules likely represents the worst case.

Two questions, not merely one, need answers:

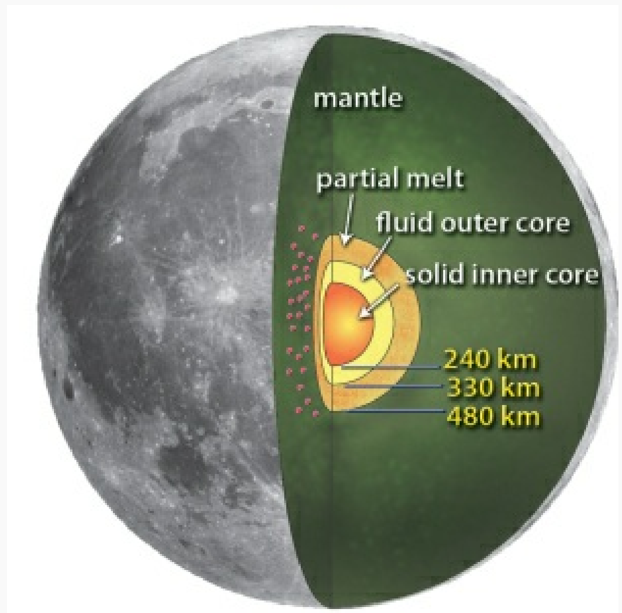
1. Could the moon have absorbed that much heat without melting through-and-through or disintegrating from the impacts? Clearly the moon did neither. It survived intact, with craters and lava flows that reflect the bombardment.
2. Does the moon hold an amount of heat *today*, that one would expect the moon to have after having 5300 years to cool off?

Why 5300 years? Because the Biblical Flood Event took place that long ago. The orbits of the comets (especially Halley and Swift-Tuttle) tell us that.

Evidence for bombardment

All scientists, conventional or creation-oriented, will stipulate the moon has suffered bombardment. Craters cover the moon's far side, and to a lesser extent the near side. The near side's smooth areas, or *maria,* represent basaltic flows. The moon also has:

1. A solid inner core and liquid outer core, similar to those of earth, and
2. A number of "mass concentrations" or "mascons," each associated with one "sea" on the near side of the moon. The five largest lie deep to Oceanus Procellarum and Maria Frigoris, Imbrium, Crisium, and Tranquillitatis. The moon has smaller mascons on the near side, deep to other maria like Sinus Medii ("Central Bay") and Mare Smythii (Smythe's Sea). The gravity map on the far side (see below) shows no high-gravity region comparable to a near-side mascon, either in area or in strength.



Cutaway of the moon showing the solid-fluid core, partial melt, and mantle, inferred from seismic data from Apollo 14, 15, 16, and 17. Diagram courtesy Renée Weber/NASA

Six two-man teams landed on the moon during Project Apollo. (A nearly crippling on-board accident forced the crew of Apollo XIII to return to Earth after one pass.) Those crews brought back samples of rock and soil that proved remarkably earth-like. Some held radioactive elements. All these samples came from or near the surface. (See here, here, and here.)

Those who suggest the moon would have melted under the bombardment, might have assumed the moon got *hot* before it got *hit*. This cannot be correct. If the age of the moon is 4.5 billion years, the moon might then have been not only molten but vaporized. No: *the moon got hot when it got hit, and because it got hit.*

The Moon also has an atmosphere, about 10^{-14} times as thick as that of Earth. Oxygen makes up most of this. Where did that come from? Probably from water that splashed onto the moon, then *dissociated* into the two elements (hydrogen and oxygen) that make up water. The hydrogen would escape; the heavier oxygen would not. (But this oxygen "atmosphere" cannot stop the meteoroids that bombard the moon to this day.)

Nicholas M. Short, in the Prentice-Hall *Planetary Geology* textbook, noticed heat flowing out of the moon, faster than anyone predicted. NASA infers this from buried thermocouple arrays that different Apollo teams left at their landing sites. Short mentions specifically Apollo XV (David Scott and James Irwin) and Apollo XVII (Eugene Cernan and Harrison Schmidt, the only PhD geologist ever to fly to the moon). In 1975 Short wrote:

> *Actual values of heat flow determined on the Moon at the Apollo 15 and 17 landing sites were two and three times higher than…predicted.*

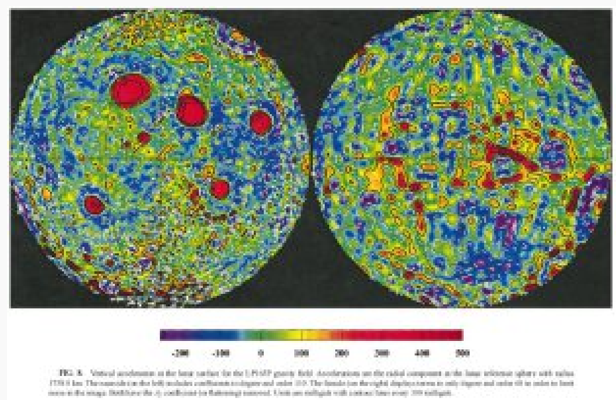
And he found this

> *a somewhat surprising outcome considering the size of the Moon and the assumption that most of its heat energy had been lost.*

In 2011, Renée Weber and her team worked out the existence of the inner and outer cores and the partial melt layer surrounding them. The diagram (above right) comes from her paper.

Tim Sharp at Space.com reports one (uncredited) guess for the lunar core temperature: 1600 to 1700 kelvins. The solid inner core contains metals that did not melt at that temperature. The earth has a much hotter core: about 6300 kelvins at the boundary between the inner and outer cores.

NASA first discovered the mascons in 1968, while Project Apollo was still running its test missions. Two years ago NASA sent this press release about the mission they called GRAIL (Gravity Recovery And Interior Laboratory; see also here and here). GRAIL used two spacecraft, communicating by laser, to map the mascons precisely. Mission controllers then compared their observations to models of large-object impacts. They concluded: *each mascon formed when a heavy object crashed into the Moon.*



Gravity map of the Moon, by Lunar Prospector. Note the five bright-red objects corresponding to known mascons deep to the five largest lunar maria. The far side (disk right) shows no comparable gravity field. Graphic courtesy NASA.

They also concluded the large objects hit the moon when it was already hot, and hotter than today. But that makes little sense. Each mascon lies deep to a lunar "sea." *The maria all have basaltic floors*. This implies a lava flow over a cool surface after the impact. Else why would the surface be any more remarkable over a mascon than, say, on the far side?

Suppose, instead, the mascon impactors, and all the other cratering impactors that fell after them, combined to *make the Moon hot?* Would that not produce the same observed findings?

When and how did this happen?

Neither Moses nor any of the Annalists (Adam, Noah, Shem/Ham/Japheth, Shem alone, Terah, Isaac, Jacob, and Joseph) he relied on for events happening before he was born, record any apparent "heavenly conflict" or anything a modern scholar might interpret as the bombardment of the moon. The bombardment cannot have happened sooner than the Global Flood. How long *after* the Flood did it happen?


Comet Shoemaker-Levy 9, broken up into 21 pieces that are about to rain down on Jupiter. Photo from the Hubble Space Telescope, courtesy of NASA, the European Space Agency, the Space Telescope Science Institute, and investigators H. Weaver and E. Smith of STScI.

NASA's mascon map gives a clue. To understand it, recall a more modern event. In July of 1994, Comet Shoemaker-Levy 9 passed too close to the planet Jupiter. It broke up into twenty-one fragments. These then fell to Jupiter. And incredibly, astronomers could *plainly see the spots where the fragments fell.* The photo at left shows Jupiter after the impacts. Notice the pattern: *beads on a string.*

The planet Jupiter, showing where the fragments of Comet Shoemaker-Levy 9 struck it. Photo by the Hubble Space Telescope, courtesy of NASA and the HST Comet Team.

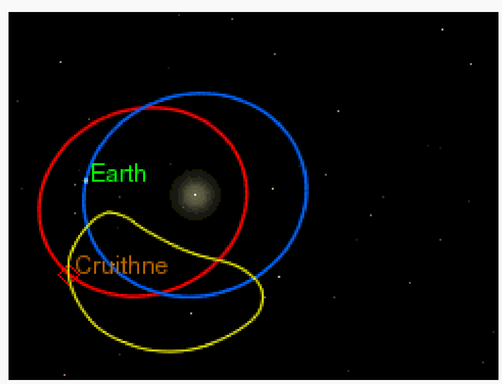
Look again at the near-side disk on the mascon map. Notice the three mascons roughly near Maria Crisium, Frigoris, and Imbrium. Like the Shoemaker-Levy 9 impact sites, they line up like beads on a string. The two other mascons to their south, lie no more than ninety degrees of arc away from this string.

Notice also: the mascon deep to Oceanus Procellarum lies southwest of the mascon for Mare Tranquillitatis. The far side of the moon has one "sea," Mare Moscoviense, to the southeast as one looks down on the moon from the second Lagrange point, opposite the moon from the earth.

These mascons sit about where they would sit, if they began as the fragments of a larger object that passed inside the moon's Roche limit and broke up. (The *Roche limit* is as close as an object can get to a larger object before tidal forces will break the smaller object apart.) Perhaps the object broke into two objects, which each broke apart again to rain down on the moon, hard enough to melt some of the moon's substance and make it flow like lava. (Brown took caution in his approach to this part of the problem. The *crossover depth* of the moon would limit the amount of lava that would flow. Brown tentatively concludes the crossover depth is at or near the boundary of the moon's liquid outer core. So any magma that formed from the impact of a future mascon would bubble up to flow as lava.)

But where could this object have come from? Any object large enough to break up to form more than five giant impactors, must be an asteroid. Asteroids, according to the Hydroplate Theory, formed after the Global Flood. Their raw material escaped the earth in the breakout of the "fountains of the great deep," as Shem, Ham, and Japheth described them (Genesis chapter 7).

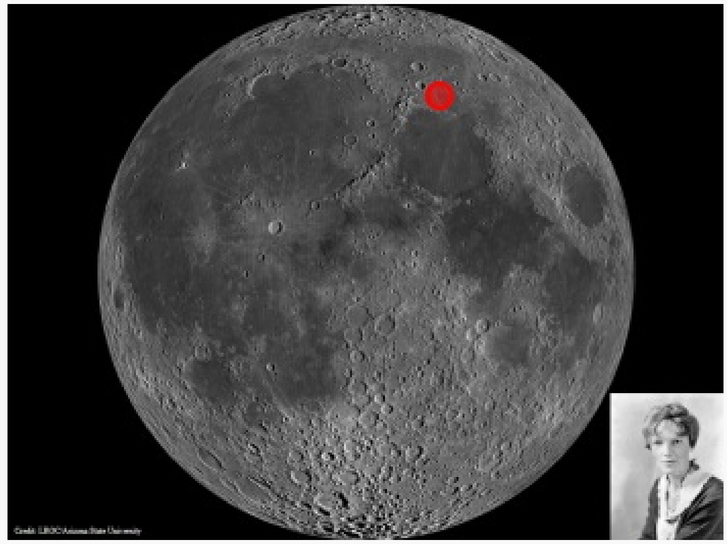
Near-earth asteroids pass close to earth more often than our highly technological civilization might find comfortable. In addition, the earth has *companion asteroids*. These follow orbits that track the earth closely and have a sidereal period of about one earth year. Asteroid 3753 Cruithne, famous for its "horseshoe orbit," is the prize example. Cruithne has a sidereal period of one year but a *synodic* period (time between closest approaches to earth) period of more than 380 years. *Nor is 3753 Cruithne the only such asteroid*. Earth has several.



Asteroid 3753 Cruithne and its apparent path from the perspective of an earth-bound observer. Graphic by User Jecowa on Wikimedia Commons, using the Celestia electronic-orrery program. CC BY-SA 3.0 Unported License.

Asteroid 3753 Cruithne is about five kilometers in diameter, thus 2.5 kilometers in radius. This would give it a volume of about 65 cubic kilometers. The moon has a density of 3100 kilograms per cubic meter, which would be 3.1 *trillion* kilograms per cubic kilometer. So perhaps 3753 Cruithne has a mass of *two hundred trillion kilograms*.

Now consider a companion asteroid at least as large as Cruithne, or larger. *Much* larger. Call it Cruithne's Big Brother, for lack of a better name. Imagine Big Brother in a horseshoe orbit, having a synodic period of about 400 years, like that of Cruithne. *Now* imagine Big Brother in an orbit *in or near the plane of the ecliptic*, instead of inclined about 19 degrees from it, like the orbit of Cruithne. This object, at a time of closest approach, passes through the Roche limit of the moon. It breaks up. Its fragments slam into the moon and turn it into the pockmarked world we know. (Three months ago NASA reported at least one crater lies *buried in basalt* on the floor of Mare Serenitatis. Clearly the seas formed *after* some of the craters did.)



Creater Earhart, named for Amelia Earhart (inset), deep to Mare Serenitatis. Photo courtesy Arizona State University. Hosted by the National Geographic Society.

But when did this happen? Again, one of the Genesis Annalists should have recorded it. And perhaps he did. Which one? Joseph, son of Israel, former steward to Potiphar, former "trusty" and almost a deputy warden at the House of the Curve (the Egyptian equivalent of Alcatraz, dug out of a sheer cliff at a curve of the Nile), and finally grand vizier of Egypt, during one of the most disastrous periods of the history of Egypt and the ancient Near East: the Biblical Famine.

In 1783, Mount Laki in Ireland erupted, with 9,000 casualties. It threw up a cloud of dust that disrupted the weather as far south as Egypt. Scientists at Rutgers University concluded: *that dust cloud reduced the flow of the Nile*, causing a famine as the annual Inundations fell below acceptable levels.

No scholar has yet traced the event that triggered the Biblical Famine: seven years of bounty, then even years in which the Inundations failed. Now consider: suppose one of the fragments of Cruithne's Big Brother fell, not to the moon, but to the *earth*? The Laki example clearly shows a big-enough meteor could kick up enough dust to affect the weather at the sources of the Nile. (The Nile begins as the union of two rivers, the White Nile and the Blue Nile.) So for seven years, the Nile fails to flood its bottom lands. Had not Pharaoh Djoser (the most likely candidate) thought to have anyone store enough food to get through that drought, the Egyptian state would not have survived. But of course the Bible tells us Djoser had two disturbing dreams of hunger wiping out plenty. Then his chief cupbearer suddenly said in effect, "Hey, I just remembered! A Hebrew trusty, down in that Hole where you sent me, predicted I would be back in your good graces in three days. Maybe you should talk to him!" With the result you know.

Let the still-skeptical reader consider this: *none* of the Genesis Annalists, except only Shem, Ham and Japheth while they kept the Log of Noah's Ark, recorded dates with any degree of precision. Instead, for instance, Jacob records tha "Reuben went, in the days of the wheat harvest, found mandrakes [*Mandragora officinarum* or some such species] growing in the field, and brought them to his mother Leah." In sharp contrast, Moses records the *precise* date of the Passover: "in the first month, in the fourteenth day of the month." He then records:

> *Now the time that the sons of Israel lived in Egypt was four hundred thirty years. And at the end of the four hundred thirty years, to the very day, all the hosts of YHWH went out from the land of Egypt. (Exodus 12:40-41, NASB)*

Four hundred thirty years before, Jacob entered Egypt (Genesis chapter 46) with all his family who didn't already live there. This happened *after* the Biblical Famine. Moses obviously could calculate the time as precisely as we can calculate it today. This strongly suggests the event that robbed the moon of its energy, and set the synodic month to its modern length, happened *before* Jacob entered Egypt but *after* Jacob left his father-in-law in Padan-Aram (ancient Syria) and returned to Canaan. The Biblical Famine is the most likely such event. We can now see it as an incidental casualty of the great bombardment of the moon.

Why didn't anyone see that bombardment? Because it likely happened during or within days of the dark of the moon. Even such high-energy impacts, enough to produce lava flows, might not have produced flashes of light anyone could see that close to the sun. (And of course, nighttime observers could see nothing at all.)

Conclusion

Dr. Brown and this correspondent have examined the evidence of the last half century. This includes the test missions of Project Apollo (VIII and X), the six successful sample-and-return missions (XI, XII, XIV, XV, XVI, and XVII), and more recent, higher-precision measurements from robotic missions (GRAIL, Lunar Prospector, and others). We conclude the moon suffered a high-energy bombardment from large amounts of water, mud, and rocks, varying in size from microscopic dust particles to the great impactors that persist as the mascons. These large impactors fell mainly on the leading face of the moon. They unbalanced the distribution of mass and thus turned that leading face toward the earth permanently in tidal lock. Before the tidal lock happened, innumerable impactors fell on the moon, predominantly during its crescent phases.

The material for these impactors first came from the breakout of a subcrustal ocean under tremendous pressure. Much of this material formed companion asteroids that fell into “horseshoe orbits” around the earth (actually around the sun but *apparently* around the earth). At least one of these companion asteroids drifted inside the Roche limit of the moon and broke up into several large fragments. These fell to the moon, started the lava flows that formed the maria, and also robbed the moon of about six percent of the orbital energy it once had. This dropped it into a lower orbit with a shorter period. But at least one fragment fell to earth. *This* high-energy impact threw up enough dust to disrupt the weather at the sources of the Nile River. This catastrophic weather change provoked the Biblical Famine, which only Divine warning stopped short of the destruction of the civilizations of the ancient Near East.

The ancient Hebrews reckoned their months by the rising and falling of the Moon and the ripening of the barley in Jerusalem. This hint about the intercalary month of *Adar sheni* suggests the Israelites “threw in” this month during the Exodus (1491-1451 BC). They likely threw it in earlier, since they first entered Egypt 430 years before that event.

The same impacts that dropped the moon into a lower and shorter orbit, also gave the moon its heat. We do not have precise-enough projections of how much heat the moon is radiating away. More-precise readings of the lunar heat flux, enough to produce a decay curve, and better modeling of the heat release from impacts from objects of different masses, might tell us over what period the slow-down of the moon occurred, and how hot the moon could have gotten, from a cold “start.” in a series of impacts starting about fifty-three hundred years before the present.