Impacts and Noah's Flood—how many and other issues

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This paper expresses the author's perspective on a number of issues regarding impacts from space occurring surrounding Noah's Flood. New data from the Lunar Reconnaissance Orbiter from 2010 provides high-resolution topographic data on the lunar surface. This new data leads to an estimate of 58,000 impacts on Earth, even larger than Michael Oard's estimate of 36,000 Earth impacts. The significance of secondary craters is considered in these estimates. Such estimates have inherent limitations that should be kept in mind. The number of known Earth impact sites is considered as well as how Catastrophic Plate Tectonics could destroy many craters on Earth.

Michael Oard is formulating a model of Noah's Flood which incorporates impacts from space as the key driving mechanism of the Flood's effects on the Earth. I applaud Oard's efforts in dealing with the issue of impacts in relation to the Flood. I have also proposed impacts took place during Noah's Flood, though, unlike Oard, I have suggested impacts could have some role in Catastrophic Plate Tectonics (CPT). The relationship of impacts to the CPT model is perhaps unclear but considering and discussing different models of Noah's Flood is a healthy exercise to refine creationist thinking. I would like to comment on some recent papers from Michael Oard related to impacts and the Flood. The first of these papers was the 2009 paper 'How many impact craters should there be on the earth?'[1] The second was the recent paper 'An impact Flood submodel—dealing with issues.'[2]

My goal in proposing impacts surrounding the Flood[3,4] has been to explain the solar system and Earth impacts from a biblical perspective, not to propose a Flood model. Still, I am very interested in Oard's effort. I would see CPT as a better model of Earth's tectonics than Oard's differential vertical tectonics. The Flood Science Review was an important project for evaluating different creationist ideas regarding how Noah's Flood took place.[5] (I was a panelist on the project.) Oard first proposed his Impacts and Vertical Tectonics model as part of that project and I would encourage creationist researchers to familiarize themselves with the e-book from the project.[5] Oard is at an early stage in developing the vertical tectonics aspect of his model. The logical connections between the impacts and the vertical tectonics seem unclear for Earth but the concept may be worth exploring.

Considering the large number of impact craters on the moon and elsewhere in the solar system, it is legitimate to ask if it is plausible to place so many impacts at the time of Noah's Flood. Oard has estimated the number of impacts on Earth at 36,000.[1] Oard based this on some cumulative crater totals counted by uniformitarian age. Oard used a minimum crater size cutoff of 30 km diameter and obtained a total of 1,831 lunar craters, which was rounded up to 1,900. This implies a total of 1,831 lunar craters of 30 km diameter and greater, up to the upper size limit valid from the statistics. The upper size limit suggested by Oard was 300 km. These are reasonable numbers from lunar crater studies; however, there is some important new crater data that now provides a more definitive crater count for the moon which will be mentioned below. From the lunar crater count, the number of craters was scaled to Earth by considering two factors about the earth, its total surface area and its gravitational cross-section.

The ratio of Earth's surface area to the moon's is 13.5. This means that Earth is a bigger target for an oncoming impactor object than is the moon. This also assumes that if you have a large number of impactors they would effectively come from all directions and be distributed across the entire surface of the planet. To account for the difference in gravity, Oard used the gravitational cross-section of 1.4. This accounts for the greater probability of an impactor striking Earth due to its stronger gravity. Oard's scaling of lunar craters to Earth then essentially entails the multiplication of these two factors, which provides a ratio of 18.9 to scale the lunar impacts to the earth. I agree with Oard's methods in this and his estimate is a good estimate, within the limitations of the technique and of the lunar crater counts. Some limitations of this method will be addressed below. Planetary scientists have done various similar estimates. However, in many crater statistics calculations the low-end-size cutoff for the craters counted is often 20 km diameter rather than 30 km. Oard's use of 30 km is a more conservative estimate that I believe is appropriate. The use of an increased cutoff size is done to prevent secondary craters from being counted as primary craters. A secondary crater is a crater made by an ejecta fragment that comes from the formation of a crater.

In 2010 the Lunar Reconnaissance Orbiter (LRO) completed global high-precision topography mapping of the moon. The Lunar Orbiter Laser Altimeter (LOLA) on the LRO spacecraft was the instrument used for this effort. The LOLA instrument is able to measure degree of slope, surface roughness, and brightness as it measures topography through use of a pulsed laser with a split beam. The LOLA altimetric measurements provide a surface mapping of unprecedented quality that has not been attained before in lunar studies. Head *et al.* indicate results give 5,185 lunar craters mapped of 20 km diameter and greater.[6] Based on figure 3B in Head *et al.*,[6] this number can be compared to Oard's crater estimate. Head *et al.* say that the new data imply significantly more craters (approximately double the number) than previous data, such as one source they refer to from 1978. The cumulative size frequency graph in figure 3B of Head *et al.* indicates that using a crater size cutoff of 30 km rather than 20 km would reduce the number of craters to approximately 60% of the 5,185 number above. This implies about 3,100 craters on the moon for crater diameters 30 km and greater. The charts in Head *et al.* show craters up to sizes of about 120 km diameter. Thus this would imply Oard's crater numbers need to be revised upward. If the 18.9 scaling factor above is applied as in Oard[1] this implies over 58,000 impacts for the earth! There are, however, some effects to consider for understanding the significance of this number and the limits of what it tells us.

Secondary craters

First of all, this kind of estimate may or may not account for all secondary craters. Crater studies assume that the number of secondary craters, formed from the ejecta from an impact, will drop off with distance from a crater. Based on the size of the crater, there are rules assumed about how far the ejecta is likely to travel from the impact site.[7] It is known that there can be unusual outliers—ejecta that travels farther than usual. Unusual outliers are not accounted for in estimates on secondary crater statistics. They are assumed to be few in number (or very small) and thus they would not throw off the crater counts for primary craters. There is a sound basis for the assumption that secondary craters drop off with distance from the impact site. This is a measurable effect around some lunar craters.[6,7] However, it is not clear if this assumption scales up the same way for the very large impacts, such as Mare Imbrium on the moon. (Mare are believed to be remnants of large impacts.) No-one is certain if all the secondaries are accounted for by the simple assumption of not counting craters below 20 or 30 km diameter. Accounting for secondary craters has also been a reason some have challenged age estimates based on crater counts.[8] Nevertheless, this is a simple technique agreed upon in crater studies to account for secondary craters. Extremely large impacts such as Imbrium on the moon could generate many secondary craters from the ejecta and they might generate craters larger than 30 km. If there are secondary craters on the moon larger than 30 km diameter, they could easily be counted as primary impacts and thereby make crater numbers too large. The question of what size to use to draw the low-end cutoff for crater counts is important. Whatever size you draw the cutoff at, the number of craters at that size accounts for most of the craters in your count because the number of impacts decreases dramatically for larger crater sizes.

In addition, a young age interpretation essentially collapses the impact timeline and this puts multiple large impact basins within a short time. The large impact basins such as the Lunar Maria would have overlapping fields of secondary craters around them. This might throw off the crater counting statistics and lead to overestimating some of the counts of smaller-sized primary craters. Scientists assume that not including craters below 20 or 30 km diameter in crater counts will keep the secondary craters from being counted with the primary craters. This is effectively Oard's assumption and it may be a valid one, but we should be aware of the possible complications from secondary craters.

Scaling craters to Earth

Crater numbers such as 36,000 or 58,000 are difficult for creationists to accept. It is a perplexing question because creationists believe Noah, the Ark, and the animals survived the Flood. It may be necessary to propose God somehow intervened to protect the Ark. But though these numbers are logical from considering the physics, it is not clear how accurate such scaling is across planets, or from the moon to Earth. As Oard indicated, the large impact basins on the moon number about 45 (figure 1).[1] But the large impacts on Mars he referred to in his Mars reference used a number of 20. The ratio of the surface areas of Mars to the moon is 3.8. So there should be more large craters on Mars than on the moon, if we were trying to scale the large craters to Mars instead of to Earth. Why would Mars have fewer large impact craters than the moon? Certainly volcanism may have destroyed or covered the evidence of significant numbers of craters on Mars. Mars possesses some of the largest volcanoes in the solar system. There are efforts today to compile new crater count data on Mars.[9] This new data will undoubtedly increase the number of known craters on Mars. On the other hand, I believe some of the proposed very large impact sites estimated as thousands of kilometres in size on Mars may not really be from impacts. The evidence is not at all clear for some sites, and we may not understand Mars's geology adequately. Thus we may not be able to determine numbers of large craters from a scaling calculation. To scale crater numbers across solar system objects is to make a statistical argument. That argument assumes that given sufficient numbers of impacts on both objects, the differences in surface area and in gravity

would reflect the impact numbers. But if the number of impactors is limited, this statistical argument does not apply.

Thus it is not valid to argue that because the moon has one impact the size of the Aitken impact (2,500 km diameter), Earth had to have 19 Aitken-scale craters. The Aitken crater on the moon is probably an unusual case. If there were enough large impacts, Earth could have that many Aitken-scale craters, but it would not have to. There are few craters in the solar system comparable to Aitken. Perhaps crater sites of this scale may be found on Earth; but thus far no-one has suggested such an impact on Earth. It is possible geologists have not yet realized how to recognize large impacts on Earth. The large impact structures are never included in the lunar crater counting statistics because of the above limitations of the crater scaling argument. Oard's 2009 paper says that the 36,000 Earth craters should include 100 over 1,000 km diameter and a few up to 5,000 km diameter.[1] I believe this overestimates the large impact structures on Earth, but there is no way to be sure. The 36,000 figure was estimated without the large impacts being included. This limitation is not due to Oard's calculation but due to the reasonable size restrictions of the crater counts from his source. Thus the scaling factor of 18.9 cannot tell anything about the number of large impacts on Earth above what was included in the statistics. So, from lunar crater counting we do not know if there would be 1 or 100 1,000-km-diameter craters on Earth. I would argue that for the largest impact structures, larger in size than what the statistics can include, we should limit the number proposed to what comes from actual observed evidence from known sites. Thus, since there are about 45 large craters and Mare on the Moon, I would expect more than this on the Earth but it does not have to be so, just because of Earth's surface area and gravity.

Image: Lick Observatory/NASA

Figure 1. The moon seen from Lick Observatory, 1999, showing the near-side Mare. The Mare represent most of the largest impacts on the moon.

We do not know how the impact bombardment at the Flood event took place. It could be possible that how the event took place could make factors other than surface area or gravity important. Perhaps there is something about the trajectory of the impactor objects that would make collisions with the moon more likely than gravity and surface area would predict. Or perhaps God timed the event in such a way that made impacts less likely on the earth and more likely on the moon. This is only to make the point that without knowing the scenario for how the impact bombardment took place we cannot be sure if there is a reliable means to scale crater numbers from the moon to the Earth. The scaling estimates of 36,000 or 58,000 may be valid for the size range they include but they should only be taken as rough estimates. The large impacts (above 300 km diameter) do not affect the total estimated number of craters. But large impacts would be responsible for most of the significant global and regional effects. There are known sites on Earth that may have been approximately 200 km in diameter but those are the largest proposed. There could be crater remnants much larger than this on Earth but I believe we should be cautious about presuming there to be many very large impacts that we do not have direct evidence for.

Destruction of craters

The number of known impact sites on Earth (see figure 2) today is best counted from an Earth crater database recently created by a geologist from Shell Oil. I will call this the Rajmon crater database after the geologist who created it.[10] The Rajmon database lists details regarding the geology of the site and ranks each site according to the clarity of the evidence of it being an impact structure. He ranks or classifies sites from 0 through 6, with 0 meaning 'Confirmed' as having shock metamorphic features that are well documented. Rajmon's class 1 sites may not have shock metamorphic features but they are well documented and other evidence argues convincingly that they are craters, such as high quality seismic data and other evidence about the site. I would prefer to use Rajmon's 0 and 1 classes to count Earth crater sites, which gives 184 as the total. This includes 175 class 0 sites and 9 class 1 sites in Rajmon.[10] There are hundreds of additional sites around the earth that have been proposed to be impact sites, but some of these have not been investigated by geologists and the evidence may be limited for many cases.

An obvious question is, if there were 58,000 impacts on Earth, what happened to them all? On Earth, the catastrophic processes of Noah's Flood could obliterate many crater structures. If the impacts began early in the Flood year and many of the impacts took place within the first several

weeks of the Flood, many craters could be destroyed so that we would not find them today. The CPT model of the Flood argues that the entire pre-Flood ocean floor was subducted into the earth's mantle.[11,12] Whether there was one continent before the Flood or not, it seems plausible that over half of the impacts could have struck in the ocean. These ocean impact craters could have been destroyed by the subduction in CPT. Impact craters on the continent would have been frequently buried under sediment, buried by lava, or could be destroyed by hydrothermal or metamorphic processes. So it seems that CPT, though impacts were not proposed to be part of the model, could very effectively wipe out evidence for a large number of craters, if most of the impacts took place early during the Flood.

Craters were undoubtedly modified or buried by events of the post-Flood period as well. Objects scattered near Earth's orbit could have occasionally fallen on Earth for some time after the Flood year. The post-Flood Ice Age would also erode or possibly bury craters from effects around ice sheets or from volcanism or other sedimentation burying the craters. All these effects together would explain how we might only find today a small number of the craters that once existed.

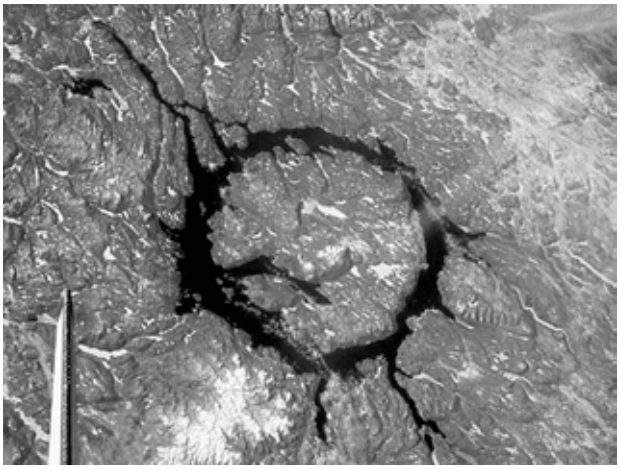

Image: LSTS-9 Crew/NASA/GSFC

Figure 2. The Manicougan impact crater in Quebec taken during the STS-9 Space Shuttle mission. At the Manicougan site most of the crater structure on the surface was eroded away.

Other issues

I would agree with a number of other comments from Oard's 'An Impact Flood Submodel-dealing with issues' paper. The discussion of impacts at the Flood brings up the obvious question of where the impactor objects came from. I agree with Oard that some source of objects outside the solar system that could somehow set off many impacts within the solar system may be reasonable.[2] I once suggested that a cloud of debris from outside the solar system could have passed through the system and set off collisions.[13] My assumption is generally that many of the small bodies in the solar system were supernaturally created in the Creation Week just as planets were, but collisions and other effects may have altered them or their orbits since the beginning. For example, some of the asteroids, perhaps the largest ones, were created as is, but many of the smaller asteroids may be collision fragments and impact ejecta. Faulkner has proposed that planets and moons might have been formed out of asteroid-like objects, but in a supernatural rapid fashion.[14,15] By this approach, the asteroid belt and Kuiper belt are areas where there are leftovers of this process. This proposal should, I think, be evaluated based on the geology of the various bodies in the solar system. There is some question whether large moons or even large asteroids could become differentiated in only about 6,000 years. Some kind of heating to melt the bodies might be necessary (such as from accelerated radioactive decay perhaps). Then with this heating comes the problem of cooling the objects in only a few thousand years.

Creationists continue to debate the issue of when the Earth impacts took place. Oard discusses the question of the reported radioactive ages of lunar samples and the time of the Late Heavy Bombardment (LHB), often mentioned by scientists.[2] It would be possible for some creationists to argue, such as Faulkner has proposed, that there were impacts during the Creation Week and again at the Flood.[14,15] I would acknowledge this is worth considering. Placing impacts from space onto Earth in the Creation Week brings up the questions of which day or days would this take place and how did life on Earth survive it? It might be necessary to propose God somehow controlled or limited the process. One might then suppose that the Early Heavy Bombardment discussed by uniformitarian scientists would be the creation impacts and the LHB impacts were at the Flood. But this would still put essentially all known observable lunar craters at the Flood. The Early Heavy Bombardment is believed to have not left much evidence on the moon due to how the surface was melted and pulverized when it took place. I would agree with Oard that there is little evidence for the Early Heavy Bombardment referred to by planetary scientists. There are very large impacts on the moon that are considered late in the LHB, so it would become a difficult question how to divide the impact sites on the moon into creation impacts and Flood impacts.

There is a similar problem with putting impacts between creation and the Flood. It seems unlikely that there were impacts in the pre-Flood time, unless perhaps it was immediately before the Flood began. However you might decide to divide the impacts between creation and the Flood, you still have very significant effects during the Flood due to the size of the impacts. If the LHB impacts are considered to be in the Creation Week, this might contradict Humphrey's magnetism model as applied to moon rocks and the decay of the Moon's magnetic field.[16] It would imply some large lava flows following Maria impacts such as Imbrium took place long before Humphreys calculated based on the

remanent magnetization. I think Humphreys' magnetic age for the moon should be considered a valid approximation. Humphreys' result may argue for the lunar Mare impacts occurring approximately at the time of the Flood since the magnetic lunar sample Humphreys referred to was representative of Mare lava flows.[16] There is a need for more research on how to interpret the radioactive dates of lunar samples from a young age perspective.

The Genesis account of the Flood is not written to describe all the mechanics of how the Flood happened. It seems to emphasize more that it was a year-long global event, and that Noah obeyed God in it. I agree with Oard that Noah may have mostly felt the effects of the Flood without seeing very much about what was happening.[2] The Genesis account does not detail how the Flood unfolded. The Flood account does, however, give some details that Noah probably could not have known, such as the water depth over the mountains. It does not even mention Noah looking out of the window the day the Flood began to see what was happening! The Flood account gives us a kind of rough outline of the event. As long as we are true to Scripture we can explore possibilities scientifically about what the details of the outline might be. So I think it is acceptable to explore the possibility of impacts during the Flood. The alternative seems to be to just ignore the crater evidence.

Conclusions

A large number of impacts during the Flood raises questions because there are many effects of so many impacts. Yet the evidence from the solar system suggests a large number of impacts occurred. I would welcome creationists exploring other possible solutions to these questions. There are also possible effects from sulfuric acid rain, powerful winds (as mentioned by Oard), and darkening of the sky for some months from ejected dust. Impacts could lead to cold temperatures for Noah early in the Flood due to the ejected dust.[17] Ocean impacts would also seem to be a very effective means of putting water in the atmosphere that could fall as rain, but whether this is what Genesis describes as "the fountains of the deep" is not clear. Volcanism during the Flood would also put large amounts of water vapour into the atmosphere that could lead to rain. I applaud Oard's effort to clarify the number of Earth impacts. However, we should be aware of the uncertainties and limitations of any estimate of the number of these. The new data from the Lunar Reconnaissance Orbiter may help clarify this number. It is not acceptable to merely assume that Earth has had only the impacts we know of today (approximately 184), because this ignores the context of Earth being one planet among others in our solar system. On the other hand, we must be careful to not overestimate the large impacts because of the limits on crater statistics. The evolutionary models of the formation of the solar system essentially assume an unlimited number of possible impactors from the planetesimals that allegedly provided the raw material for the planets. A creationist view might entail a more limited number of impactors, though still a large number. There is a need for creationists to look into scenarios of solar system events that might explain the cratering evidence.

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