Moon Craters

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Abstract

In this experiment the craters of the moon were examined. The height of the crater walls was found using their shadows, and their diameters were found as well. These two measurements were then graphed on a log log plot which was found to be linear. The energies of the impacts that cause these craters were calculated, which had a range between 1.17x10617joules to 6.29x10^21 joules. The range of masses of impact bodies was found to be 77.4x10^6kg to 4.15x10^12kg. Also mare regions were found to have less large craters compared to highland

Theory

The images were taken at a time other than the full moon as during a full moon the sun would produce the smallest shadows on the surface of the moon, thus when it is not the time of a full moon there is an appropriate shadow to use in the calculations.

Diameter and height

The diameter of each crater was calculated using the scaling provided. As for the height, which was calculated using trigonometry

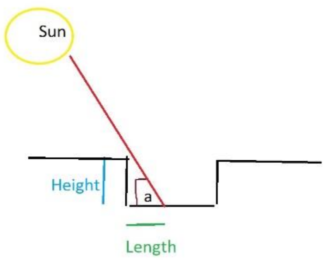


figure 1

$$Height = Ltan(a)$$

Where L is the length of the shadow and a is the angle the sun makes with the lunar horizon, which is equal to the zenith angle subtracted from 90 degrees.

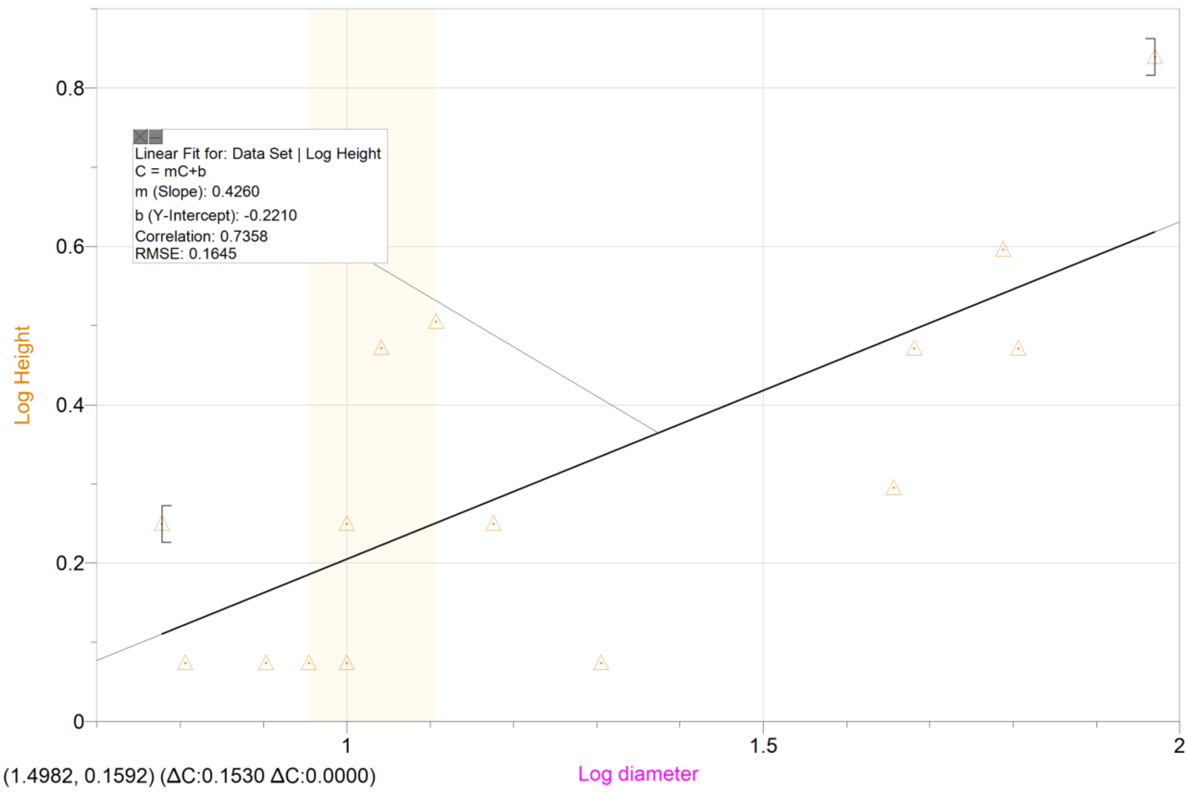


Figure 2

Diameter(m) +- 0.5km
9000
20200
10000
10000
15000
8000
11000
6400
5500
93333.33333
61333.33333
64000
48000
45333.33333
12800

Kinetic energy of impact

In order to caclulate the kinetic energy of the impact that caused each crater the following equation was used

$$D = 2.5\left(\frac{E}{\rho g_M}\right)^{1/4}$$

Where D was the crater diamter in metres, E was the kinetic energy of the impact in joules, ρ was the density of moon rock, which was taken to be $2x10^3$ kg m^{-3}, and g was the acceleration due to gravity at the lunar surface which was taken to be 1.62m/s.

The equation can also be written as $\left(\frac{D}{2.5}\right)^4 p g_M = E$

Table of kinetic energy in joules+- 5x10^15

5.44E+17
1.38E+19
8.29E+17
8.29E+17
4.20E+18
3.40E+17
1.21E+18
1.39E+17
1.07E+17
6.29E+21
1.17E+21
1.39E+21
4.40E+20
3.50E+20
2.23E+18

Dimensional analysis of equation

$$D = \left(\frac{E}{\rho g_M}\right)^{1/4}$$

$$m = \left(\frac{kg \cdot m^2 s^{-2}}{kg \cdot m^{-3} \cdot ms^{-2}}\right)^{\frac{1}{4}}$$

$$m = (m^4)^{1/4}$$

$$m = m$$

Impact velocities

The first sapce velocity is the velocity required to reach space from earth, which is approximately 7.9km/s, and the second is the velocity needed to escape earths orbit, which is 11.2km/s. This is approximately the lower bound of impact velocities, which means objects going at this velocity are have the ability to not be curtaled by earth's gravitanional pull and simlact on the moon. The third space velocity is the speed required to leave our solar system, at 42km/s which is below the typical velocity boddies around the earth and moon move at, at 50km/s. this is the main speed objects hitting the moon are travelling at, and it also means that the bodies impacting on the moon at the speed have the potential to leave our solar system.

There is a range of values of 10km/s to 100km/s as the as if impact velocity is the relative velocity of the veloity of the planet, which is 30km/s, and the veolicity of the body, which is usually 50km/s, which gives a range of 20km/s to 80km/s, and allowing for deviance from the 50km speed will give approximately a range 0f 10km/s to 100km/s.

Mass Of Bodies

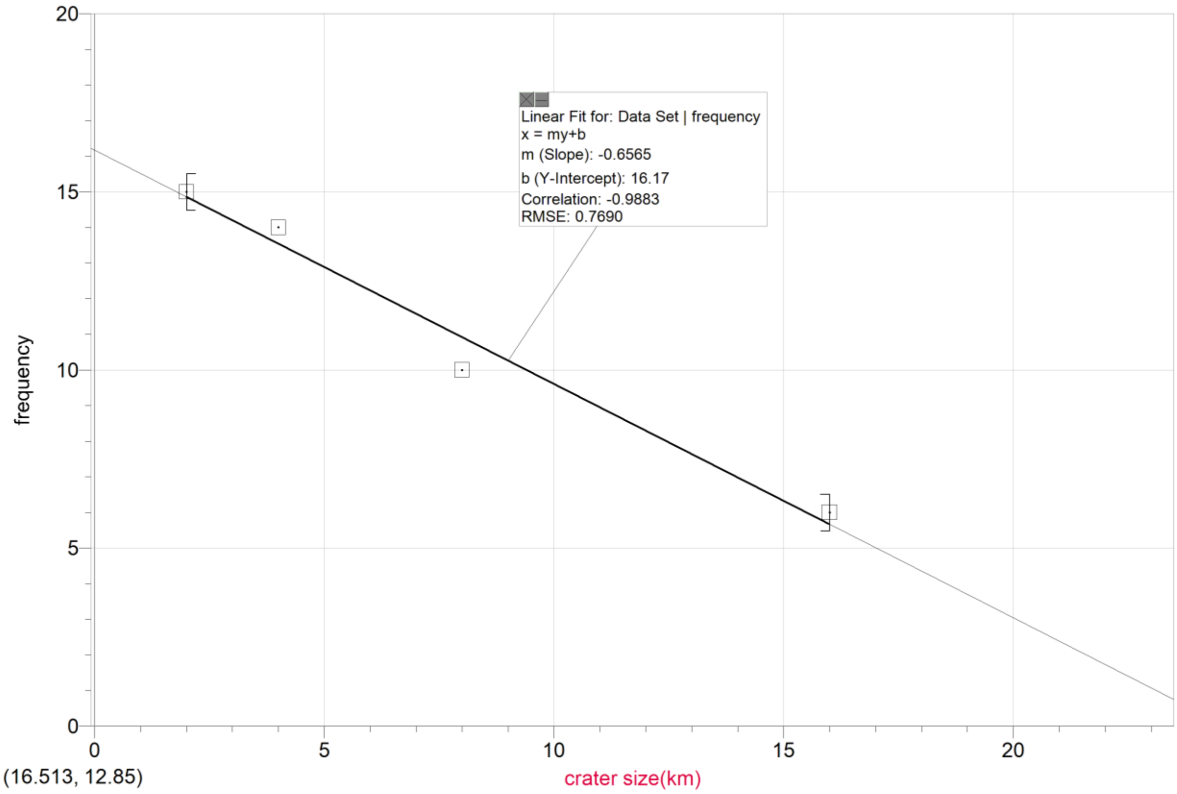
$$KE = \frac{1}{2}mv^2$$

$$\frac{2KE}{v^2} = m$$

The range of masses was found to be 77.4x10^6kg to 4.15x10^12kg, which is an appropriate result as it is in line with the range of diamters found.

Impact Crater Estimate

The percentage of craters on the moon greater than 16km in diamter was found to be 40%, greater than 8km in diameter was found to be 66.67%, with 93.33%greater than 4km in diamter and close to 100% greater than 2 km in diameter.



firgure 3

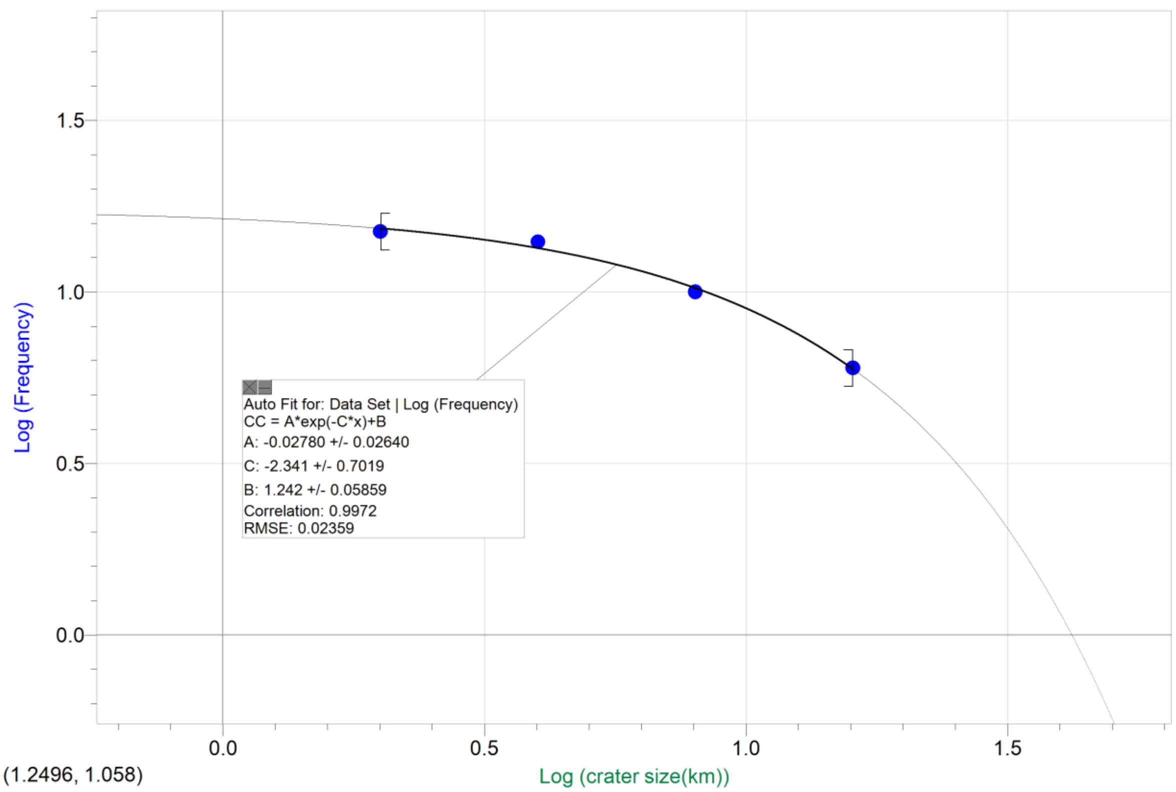


figure 4

This shows that there is a logarithmic drop off between as the size of the crater decreases, in terms of frequency. This would imply that the majority of moon craters are larger than 8km in diamter, which would mean that the importance of smaller bodies on the lunar surface are not relatively important compared to larger bodies. This could be innacurate as the areas of the moon we analysed contained quite large craters, in our case Plato, Tycho and Grimaldi.

The ratio of craters in the Mare regions compared to the highlands was found to be 1:2. This relationship makes sense as the highland area crators were formed prior to the mare region's

Solar System Formation

There are currently three prominent theories on the formation of the solar sysytem, these are the [1] Nebular Hypothesis of Laplace, the Planetesimal Hypothesis of Chamberlin and Moulton, and the Capture Theory of See. [2]The nebular hypothesis is the most widely accepted theory of the three, developed by Simon Pierre Laplace in 1796. The theory was originally without our current understanding of the important fields of gravity and nuclear forces, but has been updated as to cover these topics. The theory proposes that a nebula collapsed in on itself due to its gravity, spinning faster and flattening to form the shape of a disk. The more it collapsed the hotter and denser the material at the centre became. This eventually formed our sun, while the other material would form the planets and moons. The chemicals found in gas clouds are very similar to the chemical make up of the sun and planets and the well defined plane of rotation of our solar system lend strength the this hypothesis . [3]One of the lesser accepted proposals for the formation of our solar system is the Planetesimal Hypothesis of Chamberlin and Moulton, developed in 1905. This theory suggests that a collision between our sun and another star. The gravity of the other star is thought to have released bolts from our sun, he ones on the near side making the giant planets, while the ones on the far side making the terrestrial planets. This theory falls as the passing star seems theoretically unable to have maintained such a close distance from our sun. finally the [4]Capture theory suggests that the sun was formed before the planets, which caused the sun to rotate much slower, the terrestrial planets were formed by collisions of protoplanets near the sun, and the giants planets being formed by condensation of filament, while the moon was a wandering body "captured" by earths gravitational pull.

Experimental Procedure

Diameter of moon craters were measured with a ruler, and then scales by the scale given on each picture. The diameter was found using the largest section of the shadow in each crater and height was found using trigonometric methods. Graphs were made plotting frequency vs size of moon craters, also logarithmically

Analysis of Accuracy and Uncertainty

The moon craters we selected to measure were the largest craters on the sheet as the could be analysed with most ease, but his would create a bias o larger craters which is not a true representation of the majority of moon craters, as the majority of craters in the images were smaller than the ones we chose,. This could have lead to inaccuracies in the frequencies of our graphs.

Conclusion

A linear relationship was found between the height of crater walls and the diameter. The range of kinetic energies causing impact was found to be between 1.17x10617joules to 6.29x10^21 joules. The range of masses causing impacts was found to be 77.4x10^6kg to 4.15x10^12kg. The frequency of craters was found to decrease logarmithcally due to a decrease in size. Mare regions were found to contain less craters.

Appendix

Figure 1, height calculations diagram

Figure 2, log log plot of height vs diameter

Figure 3, plot of frequency vs size of craters

Figure 4, logarithmic plot of frequency vs size of craters.

References

1.https://www.scientificamerican.com/article/the-origin-of-the-solar-system/

2https://unacademy.com/content/upsc/study-material/general-science/the-nebular-theory-of-laplace-solar-system/#:~:text=...Read%20full-,Ans%3A%20The%20Nebular%20Theory%20of%20Laplace%20is%20a%20theory%20that,form%20our%20sun%20and%20planets.

3. https://prepp.in/news/e-492-chamberlin-moulton-planetesimal-hypothesis-geography-notes

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