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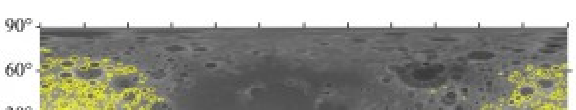
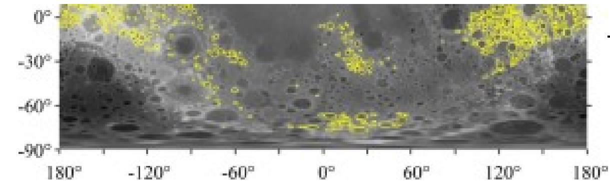
10 SEPTEMBER 2015

Asteroids have “fractured and pulverized” the moon’s subsurface (https://blogs.agu.org/geospace/2015/09/10/asteroids-have-fractured-and-pulverized-the-moons-subsurface/)

Posted by lcooper (https://blogs.agu.org/geospace/author/lcooper/)





(https://blogs.agu.org/geospace/files/2015/09/Yellow-craters.jpg)

This cylindrical projection of the moon places the nearside of the moon in the center. The study focused on 1,185 craters outlined in yellow.
Credit: Soderblom et al. 2015

By Leigh Cooper

WASHINGTON, D.C. — Large asteroids that crash into the moon cause fractures to the lunar crust that extend up to 25 kilometers (16 miles) below the moon’s surface, finds a new study. These cracks could contain a record of asteroid impacts that bombarded the inner planets billions of years ago, possibly shedding new light on the evolution of our solar system and the origin of life on Earth, according to researchers.

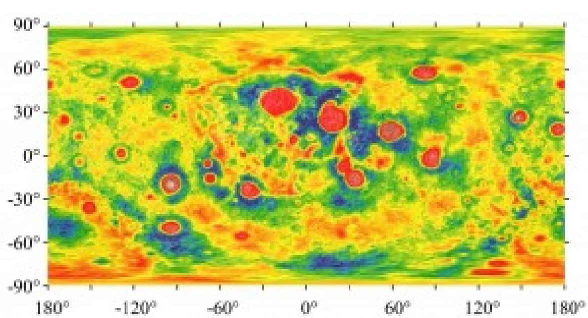
In the past, scientists have had limited options for studying the effects of an asteroid impact on the subsurface of a planet, moon or asteroid – the layer of rock above the mantle. Pristine craters don’t last long on Earth because they erode over time. Scientists can generate computer simulations of lunar impacts on the moon, but these models never account for the complexity of a real collision, according to planetary researchers.

Now, gravity field maps of the moon, generated by NASA’s Gravity Recovery and Interior Laboratory (GRAIL) mission, allow scientists to see underneath the moon’s surface. The new study uses these maps to study the subsurface deformations caused by asteroid collisions that have occurred on the moon over billions of years.

“[The new study] tells us that the entire subsurface of the moon is fractured and pulverized,” said Jason Soderblom, a planetary scientist with the Department of Earth, Atmospheric and Planetary Sciences at Massachusetts Institute of Technology in Cambridge, and lead author of the new study published in *Geophysical Research Letters* (http://onlinelibrary.wiley.com/doi/10.1002/2015GL065022/full?campaign=wlytk-41855.5282060185), a journal of the American Geophysical Union.

These subsurface structures have remained untouched by erosive forces like water and plate tectonics, potentially providing scientists with a record of lunar bombardments, Soderblom said. He hopes to be able to use the new maps to extract information about asteroid hits back to the Late Heavy Bombardment, a time about 4 billion years ago when scientists think the inner planets were pummeled by asteroids.

“I’m hopeful that we will eventually be able to provide information about the cratering history of the moon throughout its evolution,” he added.



(https://blogs.agu.org/geospace/files/2015/09/moon-2.jpg)

The nearside of the moon is centered in this cylindrical projection of the gravity anomalies across the moon. Gravity is less where the colors are cooler and greater where the colors are warmer. The map was corrected for difference in topography (known as a Bouguer correction), which also influences gravity. The study was limited to craters ranging from 27 kilometers (17 miles) to 201 kilometers (125 miles) wide; analysis of larger craters, like most of the red splotches, were outside the scope of this study. The illustration was made from GRAIL measurements.
Credit: Soderblom et al. 2015

Measuring the destructive force of asteroids

The new study looked at the gravity of 1,185 craters, all more than 27 kilometers (17 miles) in diameter that pepper the lunar highlands: the hilly, pockmarked, light-colored sections of the moon.

The gravity of a planetary body’s surface varies with sediment porosity, or the amount of space between sediments. Gravity is higher in regions where sediments are tightly compacted, and it is lower where there is more room between dirt particles.

The new gravity maps allow scientists to detect the porosity of sediments in the moon’s subsurface, which extends 25 kilometers (16 miles) below the lunar surface.

Asteroid impacts on the surface of the moon fracture the moon’s subsurface, creating pockets of space between underground sediments. Any dirt and rock tossed into the air by an asteroid collision also falls into newly-formed depressions as loose sediment. These regions with lots of empty space in the soil, or high porosity, appear as lower gravity areas on the GRAIL maps.

Scientists can use the gravity maps of individual craters to detect porosity and figure out how much fracturing of underground rock layers occurred as a result of an asteroid impact, Soderblom said.

The new research shows that, in general, the bigger an asteroid, the greater destruction it causes on the moon’s surface, fracturing sediments in a wider radius and at greater depths. The study also shows that there is a limit to how deep new pockets of space can form. Although asteroids that generate craters larger than 93 kilometers (58 miles) across disrupt more of the surface of the moon, they are unable to create more space between sediments at a certain depth, estimated to be about 25 kilometers (16 miles). The weight of the moon’s crust collapses any spaces that form at that depth, said Soderblom.

The maps also show that with each asteroid impact less than 93 kilometers (58 miles) across, the ground breaks into finer particles, continually increasing porosity, according to Soderblom. This means that the moon’s subsurface could be preserving a record of lunar cratering, Soderblom said.

David Kring, a planetary scientist with the Lunar and Planetary Institute in Houston, Texas, who was not involved with the new study, thinks the research also could shed light on the effect impacts have on different landscapes, giving scientists insight into how asteroids shaped the early crusts of planets like Earth and Mars, which were similar to the modern lunar surface.

Studying the destructive consequences of asteroid impacts could also point scientists toward the origin of life on Earth, Soderblom said. Some scientists propose that the fractured ground under craters may have been where life on Earth got started and the information gleaned from the new maps could help scientists understand the formation of these cracks, according to Soderblom.

For more information, visit the Massachusetts Institute of Technology (http://news.mit.edu/2015/moon-crust-fractured-0910) website.

— Leigh Cooper is a science writing intern at AGU.

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