Cakeraters

Demonstration

Falling space rocks collide with the surface of planets and moons to create impact craters which can be found all over our solar system

Number of Participants: 2-15

Audience: Elementary (ages 5-10) and up

Duration: 10-20 mins

Difficulty: Level 2

Materials Required:

- Brownie or cake mix (darker color preferred)
- Baking pan (any appropriate size)
- Coffee creamer or any light-colored powder
- Hot cocoa mix or any dark-colored powder (Optional)
- Phone with slow -motion capabilities (most)
- 2.54 cm Ball bearing or equivalent spherical large mass
- Rubber band (Optional)

Setup:

1. Bake the brownie according to the instructions on the box
2. Once the brownie cools down, take a teaspoonful of the coffee creamer and place it in the center of the uncut brownies. Spread uniformly across an area of 2x the diameter of the ball.
3. Optional: Place a teaspoon full of darker powder on centered on top of the lighter powder. A diameter of approximately the same as the dropped ball is suggested. This will add contrast to the crater patterns generated.

Presenter Brief:

Be familiar with how craters are formed, and their basic structure. Relate crater structures to experiences student will have had including the moon and when something is dropped in powders or liquid. Explain how meteor size, speed, and angle of incidence affect the way the craters turn out. Understand how tektites are formed.

Vocabulary:

- Meteors – Space rocks that enter a planet's atmosphere and burn up at high speeds due to friction with the gases surrounding them.

- Asteroids – Small objects made of rocks and metals that were left over from the formation of the solar system.
- Comets – Small objects made of ice, dust and rocks that were left over from the formation of the solar system.
- Meteorite – A space rock that survives going through the atmosphere and makes it to the ground.
- Crater – A large circular bowl in the surface of a planet or a moon.
- Ejecta – Material that is thrown out of the crater due to the impact. The material lands around the rim of the crater as loose material or a blanket of debris.
- Rays - Streaks of fine ejecta that are thrown out radially, due to the impact, in a very thin layer.
- Tektite – Small glassy bodies that form when molten rock, mainly silica, is ejected into the upper atmosphere, cools down and falls back to the surface.

Physics & Explanation:

Elementary (ages 5-10):

Impact craters can be seen all around the solar system. They are very prominent on the moon, mercury, mars, and even on earth. Impact craters are formed when meteorites crash into moons or planets and leave a big hole in the surface. Most rocks that are falling towards earth burn up when they reach Earth's atmosphere, due to friction, and disappear before they can make it to the surface, but occasionally a meteorite will hit Earth. As meteorites fall towards earth's surface, they gain so much energy which turns to heat.[1] When they do collide with the surface, the heat of the impact is strong enough to melt rocks and create large holes in Earth's crust.

Drop the ball bearing on top of the coffee creamer pile and watch the material get flung up and land back around the area of impact. Add more coffee creamer and experiment with dropping the ball from different heights and noting the different patterns that the coffee creamer makes and the size of the dent that the ball makes.

Have student predict how far the material will get flung when the ball is dropped from different heights.

- When meteorites hit the surface of planets or moons, they create heat that is intense enough to melt rocks alongside the surface of the planet. The force of the impact causes holes to form in the surface which are known as impact craters.
- The impacts cause material to be flung up and then they land around the crater in the form of rays.

Middle (ages 11-13) and general public:

Impact craters are big circular depressions created by impact events. Craters are the most common surface feature on the rocky planets and moons. The Moon for example

is covered by many of those depressions, that are otherwise known as impact craters. The craters formed when an asteroid or a comet collided with the Moon's surface. One distinct crater on the moon is Tycho and it is a relatively young crater, as shown if figure 1. Tycho has an impressive ray system that was sampled and examined by the Apollo 17 mission which allowed scientists to estimate the age of the crater to be 108 million years. Craters that resulted from impact events carry a lot of information about the age and nature of composition of a planet's surface. Mercury and the Moon are very similar in that they have heavily cratered surfaces, whereas Earth and Venus do not exhibit the same landforms to that extent. The difference in crater abundance stems from the lack of atmosphere and liquid water on the Mercury and the Moon. Liquid water helps erode impact craters over time while an atmosphere disintegrates meteors before they get a chance to hit the surface.[2] Earth has liquid water, wind and other erosional forces that work together to erase traces of impact craters. Craters in areas with low rain fall, do not experience as much erosion which helps keep them relatively unblemished such as Barringer crater in Arizona as shown in figure 2.[3]

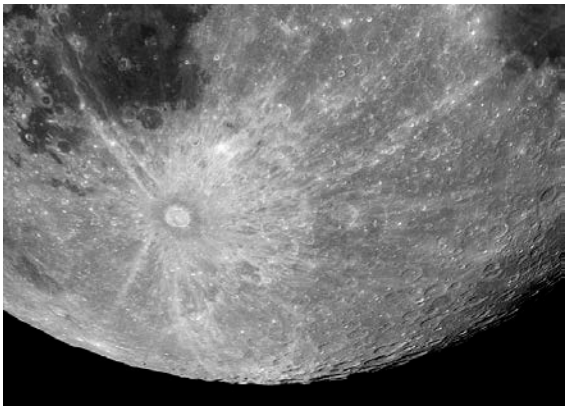

Figure 1. Moon crater, Tycho

Figure 2. Barringer crater in Arizona

Impact craters have a circular shape even though most meteorites are not spherical. That is due to material flying out in all directions as a result of the explosion from the impact. Impactors send a shock wave when they hit a solid surface, which spreads outward from the place of the impact. The shock wave is able to break rocks and empty out a large cavity in the ground, that is much larger than the impactor.[1] The impact sends material flying out in all directions. This material is known as ejecta. The ejecta lands around the rim of the crater onto the planet's surface as debris. The impactor itself gets broken into tiny pieces and may even melt or vaporize.

> Drop the ball bearing on top of the coffee creamer and note the pattern of the ejecta and the size of the crater. Try dropping the ball from different heights and angles and note the difference in the crater characteristics. Experiment with different velocities such as dropping the ball vs throwing it or using a rubber band to fling it onto the brownie. Keep track of the results using the provided worksheet.

- Impact craters are created when meteorites travel from space at high speeds and collide with the surface of planets or moons.
- Craters are circular not because the impactors are spherical, but because the pressure from the impact sends material flying in all directions and forces the rocks downward. That creates a depression in the surface of the impacted object which is surrounded by a circular rim.

Highschool (ages 14+):

Some dominant features on the surface of many of the rocky bodies in the solar systems are craters. Craters can form as a result of different events such as impacts of meteorites, volcanic activities, or explosions. Impact craters are produced when meteorites collide with the surface of a planet or a moon. Meteorites come down with great speeds, causing energetic collisions that force downward a wide area of rocks. The rocks get pulverized and a huge amount of the material is shot upward.[3] A large circular depression forms where the meteorite once was to create the crater. Most of the material falls back around the rim consequently forming patterns, such as rays, around the crater. Rays are relatively easy to see because of color variations due to them being formed from material that is coming up from under the surface which might differ in color. This change in color is simulated in this demo by layering the different colored powders and watching the color of the “ejecta” and “rays” that result from the impact.

Sometimes if the impactor is large enough, the force of the impact will push some of the material toward the edge of the crater then some of that material will collapse back toward the center and the rock beneath the crater will push back up to create a central peak as shown in the yellow square in figure 1.[4-5] The edges themselves may even collapse to create terraces that step down into the crater as shown in the red rectangle in figure 3.[6]

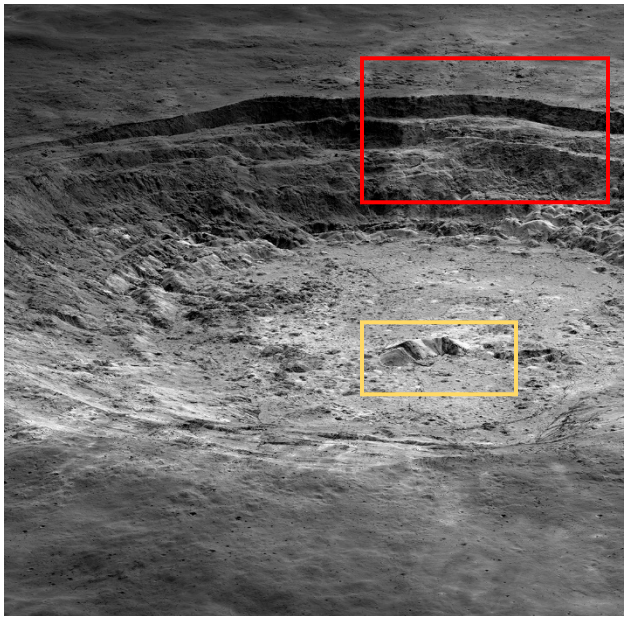

Figure 3. Complex crater showing central peak and terraces

Meteorite impacts can also pieces of silica-rich glass known as tektites. When meteorites collide with the surface of a planet or a moon, the force of the impact sends molten rocks flying upward into the upper atmosphere. There the droplets of material harden and fall back to the ground in the form of shiny glass pieces or tektites.[7]

Drop the ball bearing on top of the coffee creamer and note the pattern of the ejecta and measure the size of the crater. Try dropping the ball from different heights and angles and note the difference in the crater characteristics. Experiment with different velocities such as dropping the ball vs throwing it or using a rubber band to fling it onto the brownie. Measure the diameter of the crater, the ejecta and the height from which the ball was dropped. Keep track of the results using the provided worksheet.

Put a layer of hot cocoa mix on the brownie, coat it thinly in coffee creamer, and then add a third layer of hot cocoa mix to completely cover the white powder. Drop the ball bearing on top of the brownie and watch the color of the ejecta and the rays that form. Add more colored layers and predict which order the colored rings are going to be in. Once a hypothesis and a reasonable explanation is reached, drop the ball and see if the prediction was correct. Take slow-motion videos to help document the experiment.

- Impacts can create simple or complex craters depending on the size of the impactor. The impactor must be large enough to cause complex craters that exhibit central peaks, terraces, or multiple rings. Impact craters in this demo will only produce simple craters.
- Meteorite impacts cause material to lift off the surface as they force rocks downward to create the bowl-like hole. The material falls back around the rim of the crater as ejecta and rays.
- Both Earth and the Moon have had their fair share of impacts through history, but the Moon's craters are significantly more pronounced. The moon lacks an atmosphere and liquid water which helps preserve craters and keep them intact despite them being so old. Earth on the other hand, has an atmosphere that helps protect the surface from the smaller meteors which end up burning up and disintegrating due to the heat from friction. The atmosphere also allows wind and liquid water to exist and as a result, the erosional forces erase the existence of craters over time.
- The impacts are strong enough to melt rocks and create tektites.

Additional Resources:

- Shaping the planet: Impact Cratering, lunar and Planetary Institute https://www.lpi.usra.edu/education/explore/shaping_the_planets/impact-cratering/
- Crater, National Geographic https://www.nationalgeographic.org/encyclopedia/crater/

References:

1. Shaping the Planets, lunar and Planetary Institute. Accessed: Jul 08, 2019 https://www.lpi.usra.edu/education/explore/shaping_the_planets/impact-cratering/
2. Impact, Smithsonian National Air and Space Museum. Accessed: Jul 15, 2019 https://airandspace.si.edu/exhibitions/exploring-the-planets/online/comparing-planets/impact.cfm
3. Barringer Meteor Crater, Arizona, The planetary Society. Accessed: Jul 15, 2019 http://www.planetary.org/multimedia/space-images/earth/earth_barringer_crater_wallchan.html
4. Crater, National Geographic. Accessed: Jul 08, 2019 https://www.nationalgeographic.org/encyclopedia/crater/
5. Aristarchus Crater, NASA/GSFC/Arizona State University. Accessed: Jul 08, 2019 https://moon.nasa.gov/resources/347/aristarchus-crater/
6. Aristarchus Crater, LROC. Accessed: Jul 15, 2019 https://www.lroc.asu.edu/posts/1022
7. Tektites, Jackson School Museum of Earth History. Accessed: Jul 08, 2019 http://www.jsg.utexas.edu/npl/outreach/tektites/

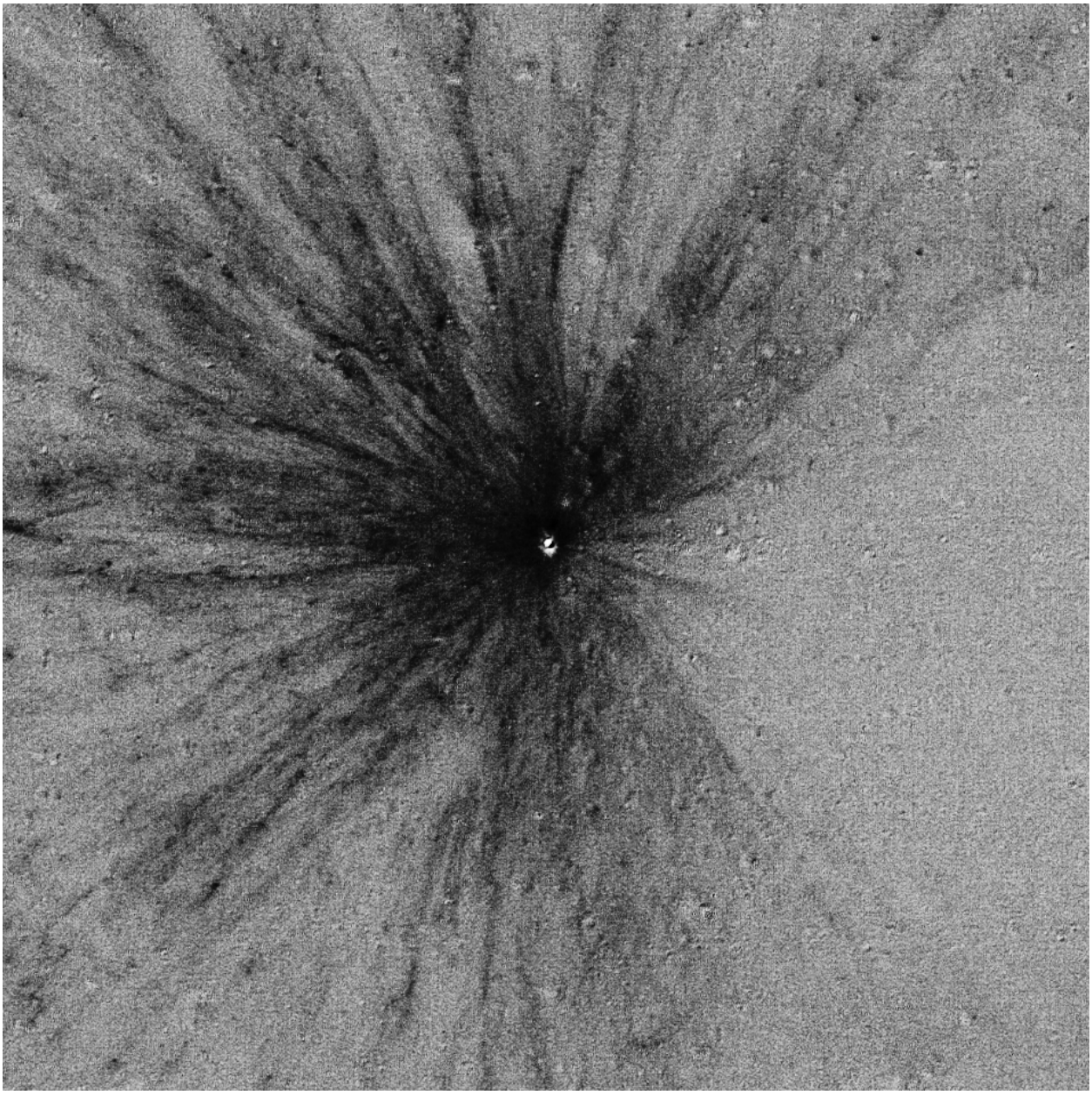

Figure 4. New crater on the moon with a significant ray pattern
NASA/GSFC/ASU

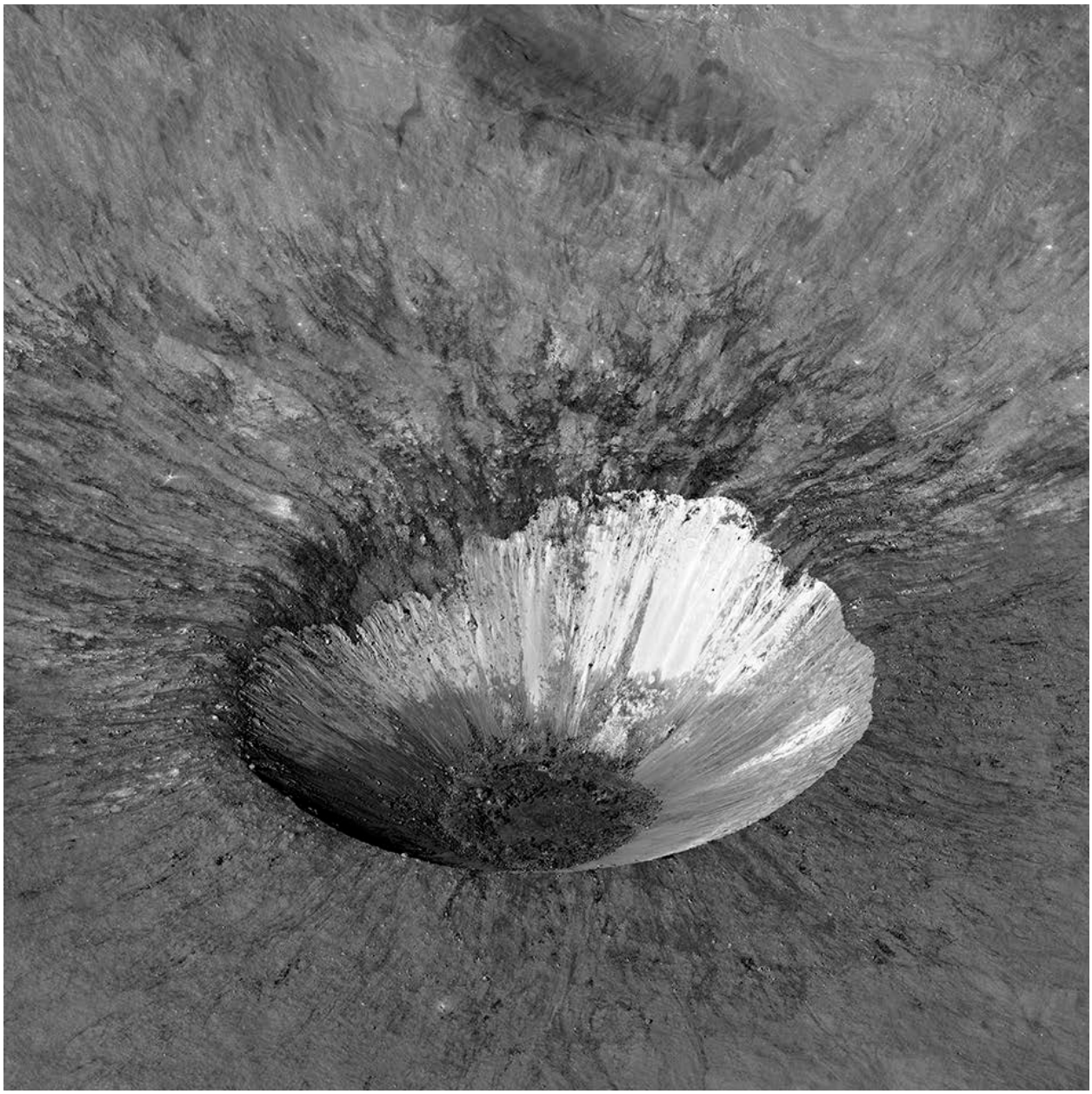

Figure 5. Hell Q crater on the moon
NASA/GSFC/ASU

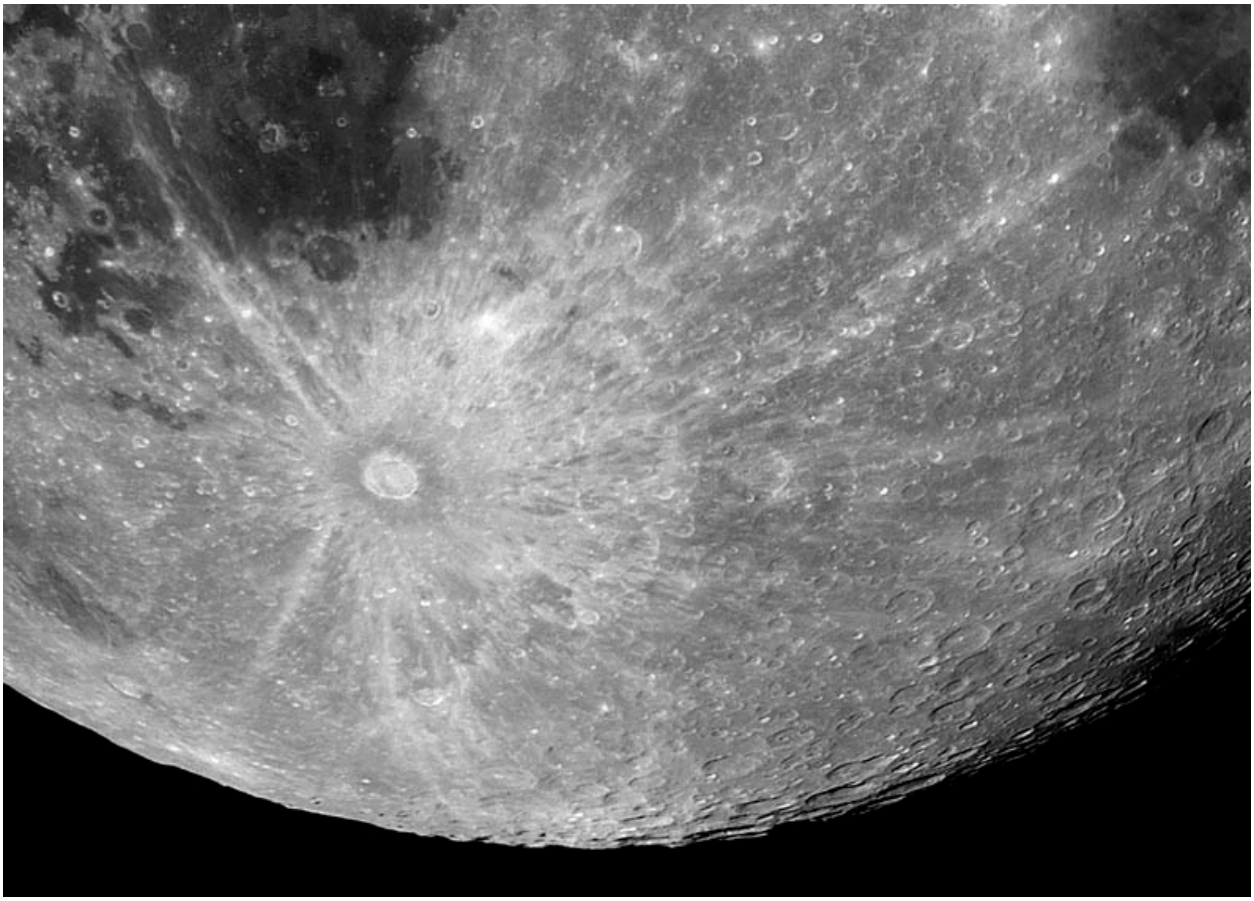

Figure 6. Tycho crater on the Moon
NASA/GSFC/ASU

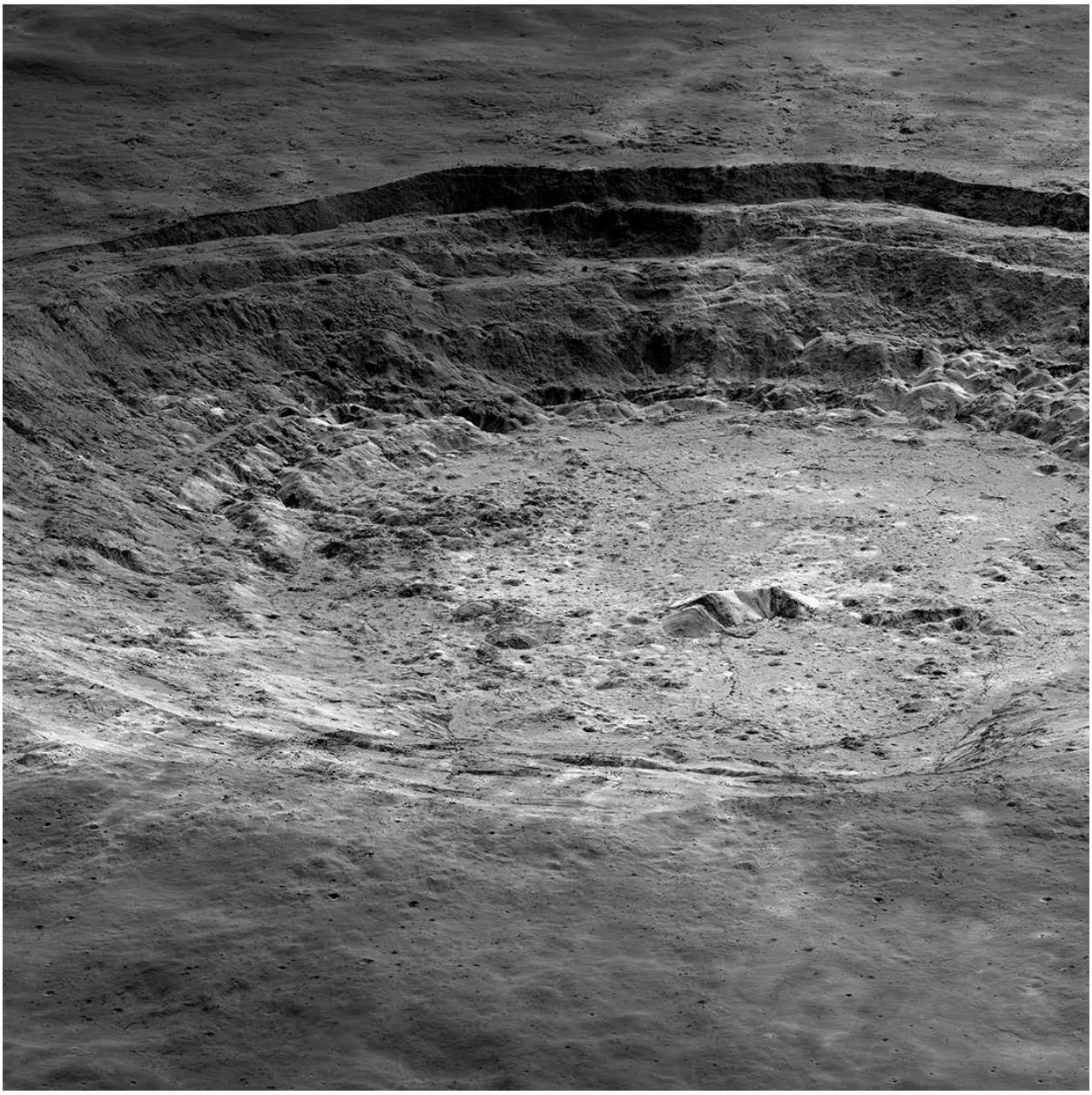

Figure 7. Aristarchus Crater is one of the most complex areas on the Moon
NASA/GSFC/ASU