



Cratering

Dark Skies, Bright Kids
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Activity Time: 40 min

Prep Time: 10 min

Grade: 3rd+

Standards of Learning Topic

- Primary SOL
 - Science 3.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
 - a) observations are made and are repeated to ensure accuracy
 - c) objects with similar characteristics or properties are classified into at least two sets and subsets
 - g) questions are developed to formulate hypotheses
 - j) inferences are made and conclusions are drawn
 - Science 4.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
 - a) distinctions are made among observations, conclusions, inferences, and predictions
 - b) objects or events are classified and arranged according to characteristics or properties
 - e) predictions and inferences are made, and conclusions are drawn based on data from a variety of sources
 - f) independent and dependent variables are identified
 - g) constants in an experimental situation are identified
 - h) hypotheses are developed as cause and effect relationships
 - Science 5.1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
 - d) hypotheses are formed from testable questions
 - e) independent and dependent variables are identified
 - f) constants in an experimental situation are identified
 - i) inferences are made and conclusions are drawn

Description

This activity uses flour and cocoa to simulate an impacted surface (e.g., the Moon) and rocks or marbles to simulate impactors (e.g., asteroids or comets). After learning how craters are formed, students make predictions about how the independent variable (an impactor's size, shape, density, speed, and impact angle) will affect the dependent variable (the impact crater). Students then design an experiment to test their predictions, make observations of their experiment, and draw conclusions from the result.



Materials

- Teacher needs
 - Aluminum pan (1 per experiment)
 - Flour (a 5 lb bag per 15 students)
 - Cocoa powder (~2 cups)
 - Pebbles varying in diameter from 0.5 to 1.5"
 - Large spoon
 - Crumpled aluminum foil about the same size as each pebble
- Each student needs
 - Activity sheet
 - Pens or pencils

Alternate Materials

- You can also use plastic or cardboard containers. Do not use glass containers because they can break.

Goals

- Illustrate how impact craters are formed
- Recognize how the characteristics of the impactor affects the final crater
- Demonstrate how to form and test hypotheses

Introduction to Topic

Craters occur when high velocity objects like meteorites impact with the surface of a planet, moon, or asteroid. The Earth, Moon, Mercury, Mars, and many other solar system bodies have craters. Venus also has craters but they are hidden below its cloudy atmosphere. Craters are generally circular but can vary in shape, generally becoming more complex the larger the impact.

Barringer (or Meteor) Crater in Arizona is a pristine example of an impact crater on the Earth. The crater is $\frac{3}{4}$ miles across and was created by a meteor about 160 feet across.

Pre-Activity Instruction

Give a lesson on cratering – how they're created and how the experiment simulates what actually happens.

Pro Tips

- Use a tarp under the experiment to simplify cleanup.

Preparation

- 1) Fill the pan with flour to about $\frac{1}{2}$ inch from the lip. The goal is to have enough flour so that the impactors do not bounce off the bottom
- 2) Sprinkle cocoa powder heavily on top of the flour to form a thin but thorough layer. This adds contrast between the surface and subsurface ejecta.

Procedure

- 1) Have students brainstorm how independent variables (impactor size, shape, mass, speed, angle) affect the dependent variables (crater width, depth, ejecta pattern).
- 2) Have students make specific predictions on the worksheet as to how the tested impactor properties will affect the crater.



- 3) The students design the experiment by choosing two impactors that differ in only one way, so students can focus on the effect of that variable.
 - a. Size: use two pebbles of different sizes.
 - b. Mass: use a pebble and crumpled aluminum foil of the same size.
 - c. Shape: pick two pebbles of approximately the same size and mass.
 - d. Impact speed: drop two identical impactors at different heights.
 - e. Impact angle: throw identical impactors at different angles with about the same force.
- 4) Have a student perform the experiment by throwing the impactors into the flour. Unless high velocities are being tested, drop the pebbles from a constant height of 3 or 4 feet.
- 5) Observe the resulting craters – how deep are they, relative to each other? How broad? What does the ejecta look like? Where did the impactor end up? Have the students record their observations on the worksheet.
- 6) Repeat these steps as many times as desired to compare different impactor properties.
 - a. When the surface becomes too mottled, use the spoon to thoroughly mix the cocoa into the flour, then sprinkle a new layer of cocoa on top. This can usually be done a few times without replacing the flour.

Safety Tips

- It can be helpful to designate a student “safety coordinator” to set a safety range that students cannot cross during the experiment. They can also be responsible for making sure the experiment goes untouched between tests.

Post-Activity Discussion

- *What was the most important impactor property tested? What effect did it have? What property seemed to have the least effect?*
Usually, pebble size will produce the most noticeable difference in crater size, followed by speed. Different impact angles produce different ejecta patterns. Pebbles of the same size but very different densities can yield noticeably different craters, and is a good demonstration of the distinction between size and mass. Pebble shape is usually not important.
- *Where do we see craters in the Solar System? What do they look like?*
Every solid surface in the Solar System has had large impacts, and the resulting craters can still be seen on many objects: the Moon, Mars, asteroids and comets, and many moons around other planets. Objects on which we don’t see many craters (e.g., the Earth, Io, Enceladus) are those with active surfaces being renewed by volcanic or tectonic activity or erosion. This experiment simulates how real impact craters form in the Solar System. A relatively small object impacts the surface, blowing a hole in the outermost layers. But because the object can’t blast all the way through, material from under the surface is thrown back out (the ejecta). Almost all craters are circular, even though most asteroids aren’t round, consistent with what the students observed in their experiment.
- *What causes them? How old do you think they are?*
Craters are most commonly caused by asteroids or comets, moving at high speeds through the Solar System and crashing into a larger body (like a planet or moon). In



the early Solar System (3 billion years ago), there were many more rocky objects than there are today, and impacts were much more common. Over time, the Solar System debris cleared out, and large impacts are relatively rare today.

- *Why are craters important? What do they tell us about our Solar System's history?*

Many solar system objects (like our Moon) do not have any ongoing surface activity, which is the only way of “erasing” an impact crater. Thus, scientists can use the quantity and arrangement of craters to tell how old a surface is! For example, the Moon has many craters that overlap each other, while Earth only has a few, spread far apart. This tells us that although the Earth and Moon are roughly the same age, the Earth's surface is much younger. This is because the Moon stopped its volcanic activity long ago. Similarly, we have found moons around Jupiter and Saturn with very few (or no) craters, indicating that these moons still have interesting activity in their interiors!

Extensions and Related Activities

- Related activities and lessons
 - Comets – A Physical Model

Resources

- NASA has many good activities, including a middle-school variation of this experiment http://www.nasa.gov/pdf/180572main_ETM.Impact.Craters.pdf
- CosmoQuest has several activities relating to craters on Solar System objects <http://cosmoquest.org/mappers/moon/>
<http://cosmoquest.org/mappers/mercury/>
<http://cosmoquest.org/mappers/vesta/>

Glossary

- *Asteroid* – A small rocky body orbiting the sun, ranging from hundreds of feet to hundreds of miles across. Large numbers of these reside in the asteroid belt located between Earth and Jupiter.
- *Ejecta* – Material thrown out as a result of meteoritic impact.
- *Impact* – The collision of a meteoroid with the surface of a large Solar System object.
- *Impact Crater* – A large bowl-shaped cavity on the surface of a Solar System body caused by the impact of a meteorite.
- *Meteor* – A bright streak in the sky caused by a meteoroid traveling through the atmosphere.
- *Meteorite* – A mostly-metal meteor that survives its passage through the Earth's atmosphere and impact with Earth.
- *Meteoroid* – A small body traveling through space, often the remnant of a comet.