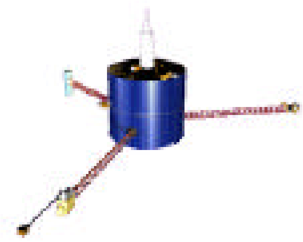


Space Day: Prospecting for Knowledge

16-Make a Crater – Teacher Page

Purpose: To determine the factors affecting the appearance of impact craters and ejecta.

Background: The circular features so obvious on the Moon's surface are impact craters formed when impactors smashed into the surface. The explosion and excavation of materials at the impacted site created piles of rock (called ejecta) around the circular hole as well as bright streaks of target material (called rays) thrown for great distances.

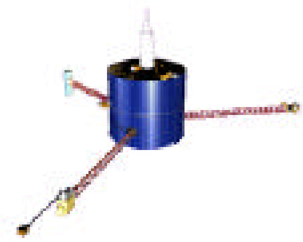
Two basic methods that form craters in nature are: 1) impact of a projectile on the surface and 2) collapse of the top of a volcano creating a crater termed caldera. By studying all types of craters on Earth and by creating impact craters in experimental laboratories, geologists concluded that the Moon's craters are impact in origin. The factors affecting the appearance of impact craters and ejecta are the size and velocity of the impactor, and the geology of the target surface.

By recording the number, size, and extent of erosion of craters, lunar geologists can determine the ages of different surface units on the Moon and can piece together the geologic history. This technique works because older surfaces are exposed to impacting meteorites for a longer period of time than are younger surfaces. Impact craters are not unique to the Moon. They are found on all the terrestrial planets and on many moons of the outer planets.

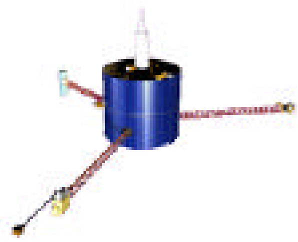
On Earth, impact craters are not as easily recognized because of weathering and erosion. Famous impact craters on Earth are Meteor Crater in Arizona, U.S.A.; Manicouagan in Quebec, Canada; Sudbury in Ontario, Canada; Ries Crater in Germany, and Chicxulub on the Yucatan coast in Mexico. Chicxulub is considered by most scientists as the source crater of the catastrophe that led to the extinction of the dinosaurs at the end of the Cretaceous period. An interesting fact about the Chicxulub crater is that you cannot see it. Its circular structure is nearly a kilometer below the surface and was originally identified from magnetic and gravity data.

This Activity: In this activity, marbles or other spheres such as steel shot, ball bearings, or golf balls are used as impactors that students drop from a series of heights onto a prepared "lunar surface." Using impactors of different mass dropped from the same height will allow students to study the relationship of mass of the impactor to crater size. Dropping impactors from different heights will allow students to study the relationship of velocity of the impactor to crater size.

Preparation: Review and prepare materials listed on the student sheet. The following materials work well as a base for the "lunar surface." Dust with a topping of dry tempera paint, powdered drink mixes glitter or other dry material in a contrasting color. Use a sieve, screen , or flour sifter. Choose a color that contrasts with the base materials for most striking results. All purpose flour (reusable in this activity and keeps well in a covered container); Baking soda (it can be recycled for use in the lava layering activity or for many other science activities). Reusable in this activity, even if colored, by adding a clean layer of new white baking soda on top. Keeps indefinitely in a covered container. Baking soda mixed (1:1) with table salt also works. Corn meal (reusable in this activity but probably not recyclable. Keeps only in freezer in airtight container.). Sand and corn starch mixed (1:1), sand must be very dry. Keeps only in freezer in airtight container. Pans should be plastic, aluminum, or cardboard. Do not use glass. They



should be at least 7.5 cm deep. Basic 10"x12" aluminum pans or plastic tubs work fine, but the larger the better to avoid misses. Also, a larger pan may allow students to drop more marbles before having to resurface and smooth the target materials. A reproducible student "Data Chart" is included; students will need a separate chart for each impactor used in the activity.



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16-Make a Crater – Student Page

Purpose: To determine the factors affecting the appearance of impact craters and ejecta.

Materials: 1 pan; "lunar" surface material; tempera paint, dry sieve or sifter, balance, 3 impactors (marbles or other spheres); meter stick, ruler, plastic with middle depression; protractor; "Data Chart" for each impactor; graph paper.

1. Making an hypothesis:. After looking at photographs of the Moon, how do you think the craters were formed? What do you think are factors that affect the appearance of craters and ejecta?

2. Preparing a "lunar" test surface: Fill a pan with surface material to a depth of about 2.5 cm. Smooth the surface, then tap the pan to make the materials settle evenly. Sprinkle a fine layer of dry tempera paint evenly and completely over the surface. Use a sieve or sifter for more uniform layering. What does this "lunar" surface look like before testing?

3. Use the balance to measure the mass of each impactor. Record the mass on the "Data Chart" for this impactor. Drop impactor #1 from a height of 30 cm onto the prepared surface. Measure the diameter and depth of the resulting crater. Note the presence of ejecta (rays). Count the rays, measure, and determine the average length of all the rays. Record measurements and any other observations you have about the appearance of the crater on the Data Chart. Make three trials and compute the average values.

4. Repeat steps 2 through 5 for impactor #1, increasing the drop heights to 60 cm, 90 cm, and 2 meters. Complete the Data Chart for this impactor. Note that the higher the drop height, the faster the impactor hits the surface. Next, repeat steps 1 through 6 for two more impactors. Use a separateData Chart for each impactor. Graph your results. Graph #1 is Average crater diameter vs. impactor height or velocity. Graph #2 is Average ejecta (ray) length vs. impactor height or velocity. Note: on the graphs, use different symbols (e.g., dot, triangle, plus, etc.) for different impactors.

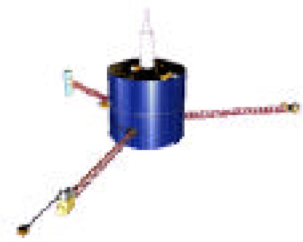
Results:

1. Is your hypothesis about what affects the appearance and size of craters supported by test data? Explain why or why not. What do the data reveal about the relationship between crater size and velocity of impactor. What do the data reveal about the relationship between ejecta (ray) length and velocity of impactor.

2. If the impactor were dropped from 6 meters, would the crater be larger or smaller? How much larger or smaller? Explain your answer. (Note: the velocity of the impactor would be 1,084 centimeters per second.) Based on the experimental data, describe the appearance of an impact crater.

3. The size of a crater made during an impact depends not only on the mass and velocity of the impactor, but also on the amount of kinetic energy possessed by the impacting object. Kinetic energy, energy in mostion, is described as: where, m = mass and v = velocity. During impact, the kinetic energy of an

Activity courtesy of University of Hawaii Institute of Geophysics and Planetology



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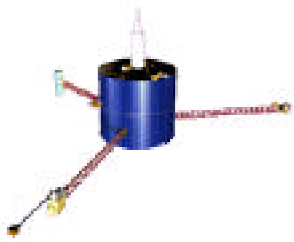
asteroid is transferred to the target surface, breaking up rock and moving the particles around. How does the kinetic energy of an impacting object relate to crater diameter?

4. Looking at the results in your Data Tables, which is the most important factor controlling the kinetic energy of a projectile, its diameter, its mass, or its velocity? Does this make sense? How do your results compare to the kinetic energy equation? Try plotting crater diameter vs. kinetic energy as Graph #3. The product of mass (in grams) and velocity (in centimeters per second) squared is a new unit called "erg."

Data Chart

Drop Height = 30 cm (Velocity = 242 cm/s)					
	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					
Average Length of all Rays					
Drop Height = 60 cm (Velocity = 343 cm/s)					
	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					
Average Length of all Rays					
Drop Height =90 cm (Velocity = 420 cm/s)					
	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					
Average Length of all Rays					
Drop Height = 2 meters (Velocity = 626 cm/s)					



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	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					
Average Length of all Rays					

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