Cosmic Collisions

Activity: Impact Cratering

by Ronald Greeley, Arizona State University (Adapted from the NASA workbook, *Activities in Planetary Geology*)

Materials

- A tray or very strong box at least 2 feet on a side and about 4 inches deep
- A large supply of extremely fine sand
- Four identical marbles or small ball bearings
- Three solid spheres about 1 inch in diameter, all the same size but made of different materials, for example, glass, plastic, steel; or glass, wood, aluminum)
- Meter stick
- 10-centimeter ruler
- Toy Slingshot (Optional)
- Kitchen tea strainer
- Dark color of dry tempra paint (powder); for example, red or blue
- Safety glasses or goggles
- Large pack of assorted marbles
- One steel ball bearing about 1/2'' in diameter

Procedure

Pour sand into the tray to a depth of at least 3 inches. Smooth the surface of the sand with the edge of the meter stick. Divide the surface into two equal areas.

Importance of Mass of the Impacting Object on Craters

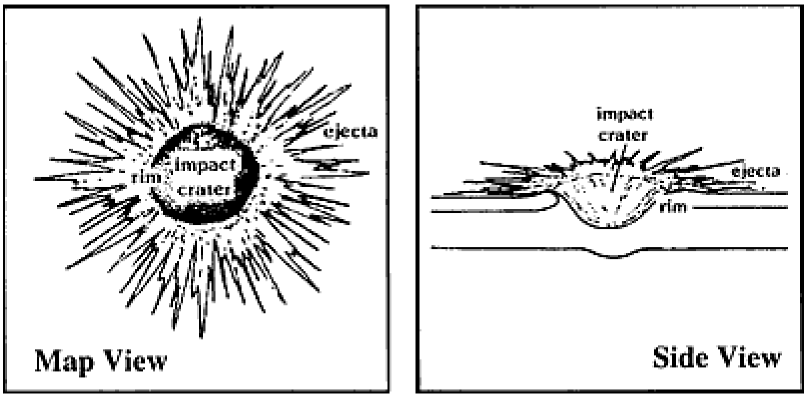
From a height of 2 meters (6 feet), drop each of the large spheres (three different types) into one area. Carefully measure the diameter of the craters formed by the impact without disturbing the sand. Students should then be asked to answer the following questions (answers in parentheses):

- Which sphere created the largest crater? (*The most massive.*)
- What is the only difference in the way each crater was made? (*The mass was varied.*)
- Each sphere represents a meteorite. What can you say about the importance of the mass of a meteorite in making a crater? (*Crater diameter increases with increasing mass.*)

Importance of Velocity of the Impacting Object on Craters

Drop the four identical marbles into the second area, each from a different height, from 10 cm up to 2 meters. If desired, the third and fourth marbles can be launched from an extended slingshot 23 cm (9 inches) and 36 cm (14 inches) above the sand, and aimed directly down into the sand. CAUTION: THE SLINGSHOT IS A POTENTIALLY HAZARDOUS DEVICE. USE EXTREME CAUTION WHEN IT IS EMPLOYED IN THIS ACTIVITY. UNDER NO CIRCUMSTANCES SHOULD IT BE AIMED HORIZONTALLY. Without disturbing the sand, carefully measure the crater diameter. Students should then be asked the following questions:

- In this case, each marble (meteorite) had the same mass. What did dropping marbles from different heights (and propelling two marbles, if the slingshot was used) accomplish? (*This varies the velocity at impact.*)
- Did you measure any difference in the diameters of the craters? (*Yes, as velocity increases, so does crater diameter.*)
- Besides diameter, do you notice any other difference in appearance among the craters? (*No, all look qualitatively similar.*)
- Which do you think is more important in creating larger craters, more mass or more velocity? (*Velocity increases have more effect on crater diameter than mass increases. Velocity has a greater contribution to the energy of impact.*)



An ideal example of a fresh crater.

The Structure of a Crater

Remove all marbles and spheres from the sand and smooth the surface well. Again divide the tray into two areas. Sprinkle a very fine layer of dry tempra color over the sand using the tea strainer. The layer of colored powder should cover the surface just enough to conceal the sand. CAUTION: WEAR SAFETY GOGGLES AND BE SURE THAT NO GLASS OR BREAKABLE MATERIALS ARE IN THE VICINITY OF THE ACTIVITY.

Use the slingshot to shoot the 1/2'' ball bearing vertically into the sand. DO NOT DISTURB THE RESULTING CRATER IN THE FOLLOWING STEPS. Draw two pictures of the crater, one looking down from above (map view), and one as seen from *ground level* (side view). Label the drawings with the words rim, ejecta and impact crater (see sample diagrams). Notice the sharp details of the crater. Ask the students the following questions:

- Where do you find the thickest ejecta? (*On the rim.*) What do you think caused the crater rim to form? (*Sand scooped out by the impact was deposited on the rim.*)

- The colored powder represents the most recent sediment deposited on a planet's surface. Any material beneath the top layer must have been deposited at an earlier time (making it physically older). If you were examining a crater on the Moon, where would you probably find the oldest material? Why do you think so? (*Near the rim. Because the deepest material ejected lands closest to the crater, i.e., on the rim.*)

Cratering on the Moon

In the second area create another crater using the 1/2" ball bearing. Drop each marble from the pack of assorted marbles from an arbitrary height into the second area so that each one impacts at a different speed. Be careful to drop the marbles near but not directly on top of the crater formed by the slingshot method. Watch the process very carefully as you do it. Ask the students the following questions:

Craters in the Tycho-Clavius region of the Moon.

- How does the appearance of the original crater change as you continue to bombard the area? (*It loses its crispness.*)
- Look at a photograph of craters on the Moon (see photo or use one taken from a book). Do all the craters have the same fresh, sharp, new appearance? Describe the various appearances? (*No — smooth rims to sharp rims, bowl-shaped to elliptical, etc.*)
- What do you think has happened in this area? (*Long-term bombardment.*)
- What do you think is an important source of erosion on the Moon? (*Impact cratering.*)
- What does the appearance of a crater tell you about its age? (*The younger the crater, the crisper the features; the older, the more subdued.*)

A note on procedure

This activity was developed for a high school science students. Impact craters can be demonstrated with younger or less advanced students using mud instead of sand and ball bearings. Add water to dirt until the mud has the consistency of thick cake batter, or until it slowly drips off a spoon. Then drop spoonfuls of mud onto a pie pan full of the thick mud to create craters. For more details on this variation, see *Ranger Rick's Naturescope - Astronomy Adventures* by the National Wildlife Federation (1989), or *Astronomy for Every Kid,* by Janice Van Cleave (John Wiley and Sons Publishers, 1991).

For further reading about cosmic collisions

- Chapman, C. and Morrison, D. *Cosmic Catastrophes.* 1989 Plenum Press. [See excerpts in the Nov/Dec 1989 and Jan/Feb 1990 issues of Mercury magazine.]
- Goldsmith, D. *Nemesis.* 1985 Walker.
- Gould, S. "An Asteroid to Die For'' in *Discover,* Oct. 1989, p. 60.

- Morrison, D. and Chapman, C. "Target Earth: It Will Happen'' in *Sky and Telescope,* Mar. 1990, p. 261.
- Sinnott, R. "An Asteroid Whizzes Past the Earth'' in *Sky and Telescope,* July 1989, p. 30.
- Weissman, P. "Are Periodic Bombardments Real?'' in *Sky and Telescope,* Mar. 1990, p. 266.