From Space to Earth: Meteor Crater

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Teacher Lesson 3: What If…? Experimenting with Impact Scenarios

Overview

Look at images of the Moon, Mercury and Mars and you will see craters of many different sizes. The final crater size or diameter depends on many initial conditions. Some of the most important include: the size of the impactor; the density of the impactor (icy or stony or iron); the strength of the target (sedimentary target versus volcanic; soil versus bedrock); the impact velocity; and the gravity of the planet. Barringer Meteor Crater was created by a nickel- iron impactor relatively small compared to the size of the crater.

What if a different-sized meteorite traveling at a different velocity had crashed at the site of The Barringer Meteorite Crater? What would the resulting crater have looked like? How would the environmental effects have been different? This activity links students to the interactive Earth Impact Effects Program developed by Marcus, Melosh, and Collins at University of Arizona. Using the simulation, students will investigate how impact parameters affect the resulting crater and its environment.

PURPOSE

Students will conduct a controlled experiment using an online simulation tool to see how impact parameters such as the size and density of the projectile, impact velocity and angle, and the type of target material determine the resulting crater and its impact on the environment.

COMPLETION TIME

2 class periods/hours

LEARNING OBJECTIVES

Students will learn about some of the different variables that affect the resulting size of a crater: characteristics of the projectiles, velocity, impact angles and target materials.

Students will use an online simulation to calculate the effects of initial conditions.

Students will change one input variable in the simulation while keeping all other variables constant.

TOOLS/MATERIALS

Computer/online access

Images of craters on the Moon, Mars, and Mercury and the Barringer Meteorite Crater

Link to the student data sheet - “What If…? Experimenting with Impact Scenarios ”

Links to the teacher keys

Procedure

BEFORE THE ACTIVITY

Share the student data sheet – “What If…?”

Access the teacher answer keys

ON THE DAY OF THE ACTIVITY

1. Ignite Curiosity about Impact Crater Size (10 minutes)

- Show them the image of Barringer Meteor Crater https://en.wikipedia.org/wiki/Meteor_Crater#/media/File:Barringer-1001.jpg

- Ask students to think of all the variables during an impact event that affect the size of an impact crater.

- Discuss their answers and list the correct ones on a slide (different sized impactors; different velocities; different mass and density of the impactors, gravity of a planet, atmosphere, angle of impact, density of target)

(Note: The gravity of a planet also affects the final crater size. For a given impactor at a given velocity, the resulting crater will be larger on the Moon (lower gravity) than on the Earth (higher gravity). This is mainly because in the lower gravity environment, ejecta can travel farther and more material will leave the crater.)

- Ask them: What if the initial conditions for the Barringer Meteor Crater impact had been different? What if the impactor had been bigger or smaller in diameter? What if the velocity had been different? (On the question about velocity, mention that the simulation talks about the possibility of the projectile breaking up in the atmosphere and having a different final velocity. Projectiles can be slowed down somewhat and broken up by the Earth’s atmosphere. This will not occur on planetary bodies with no atmosphere, like the Moon or Mercury.)

2. Describe the Simulation "Earth Impact Effects" (5 minutes)

- Tell them they will get a chance to find out what could have happened by changing some parameters using a simulation called the Earth Impact Effects Program developed by scientists studying impact cratering (Marcus, Melosh, Collins).
- Explain that the program will ask them to input some data (initial conditions) such as the distance from the impact point, projectile diameter and density, impact velocity and angle, target type.

3. Lecture: Define Key Variables (10 minutes)

Type the following terms on a slide and ask students to explain them as they follow along with the data sheets.

Distance from Impact: How far away from the impact will the effects be observed?(If you were standing at this distance how would it affect you?)

Projectile Parameters:

Diameter- How big is the projectile?

Density of the projectile - Type of projectile (ice, porous rock, dense rock, iron). Choose from the list and it will give you the density.

Impact Parameters:

Velocity before it enters the atmosphere (measured in km/s because they move so fast!)

Impact angle measured from a plane tangent to the surface (90 degrees is a vertical impact).

Target Parameters:

Type of target: water (how deep?), sedimentary, or crystalline rock.

Joule: A scientific unit of energy (equal to the work required to move 1kg of mass against an opposing force of 1 Newton) *A glossary is available for other terms by clicking on the links on the simulator.*

4. Model how to use the Earth Impact Effects Program (10 minutes)

Go to the Earth Impact Effects Program. Earth Impact Effects Program: *http://www.lpl.arizona.edu/impacteffects/*

Use the data listed below for the impact at Barringer Meteorite Crater to model how to use the simulator.

Distance from impact: **20 km**
Projectile Diameter: **45m**
Projectile Density: **iron/8000kg/m3**
Impact Velocity: **20k/sec**
Impact Angle: **45 degrees**
Target Density: **2500kg/m3**
Target type: **Sedimentary**

Explain that the calculated results will give them much more information than they will need and that they will only need to document the information asked for on the data sheet.

Explain that all values in the calculated results are approximations or estimates, as stated on the top of the webpage.

Note: Questions may arise when students see the type of crater formed (simple, complex). Tell them that you will explain the difference after the activity.

5. Students Use Earth Impact Effects Simulation (40 minutes)

Testing for A. Projectile Diameter -or- B. Impact Velocity

Divide the class into two (and make several groups within each half), giving each half of the class a different variable to change (see teacher key). Caution them to change ONLY the variable they have been assigned.

Explain they will be doing three trials - changing their variable three times.

Demonstrate to the class how to input Barringer Crater data results (Energy, etc.) and answer any questions about definitions.

Give them about 30-40 minutes in their breakout groups to accomplish the data gathering.

6. Discuss Simulation Result (15 minutes)

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- What did the students learn about the effect of projectile speed and impactor diameter on the resulting impact event?

- What other lessons did students learn about impact events from using the simulation?

- What questions about impact craters does the class have now?

ASSESSMENT CRITERIA

Did the student communicate an understanding of the conditions for the experiment? (changing only one variable)

Did the student communicate an understanding of the relationship between the input conditions and the resulting data?

Was the student able to work the simulation with little or no help?

Completion of work in the allotted time.

EXTENSION

Consider changing Impact angle to 10, 25,40, and 55 degrees; and/or changing the density of the projectile!

Links

Earth Impact Effects Program: *http://www.lpl.arizona.edu/impacteffects/*

Guidebook to the Geology of Barringer Meteorite Crater, Arizona (Kring, 2007), Courtesy of Dr. David A. Kring: *http://www.lpi.usra.edu/publications/books/barringer_crater_guidebook/*

Activity design by Lollie Garay in collaboration with Dr. Carolyn Ernst.