Making Craters Activity - Notes for Teachers

Objective

The aim of the inquiry-based activity is to expose students to planetary surface processes. On Earth, many factors (including wind, water, tectonic, and volcanic activity) play a role in shaping the landscapes we see. Elsewhere in our solar system, however, these processes are muted by one major process – impact cratering. This student-designed lab focuses on understanding the factors that play a role in the resulting crater formed after an impact.

Overview

- Before the event:
  - The teacher will provide brief overviews of the event and the activity to the students.
  - The teacher will collect and prepare the materials and pans for the activity.
- During the event:
  - Each student group will choose their independent variables and design their own experiment.
  - Proposed experiments are to be approved by the teacher.
- After the event:
  - Students will record their results and draw conclusions from their experiments.

Outcomes

Students will leave this activity with:

- An understanding of the primary process affecting planetary surfaces,
- A stronger knowledge of planets, asteroids, comets, and meteorites, and
- The ability to employ the scientific method to design, execute, and assess the success of an inquiry/experiment.

Live Webinar Information

The live webinar event will run on September 18th from 1:00 PM to 2:00 PM ET. The activity will begin with a 10-minute presentation on craters and impacts, followed by 5 minutes of introduction to the activity. The students, in groups, will then design their experiment. The students will have 30 minutes to conduct two different investigations before the webinar's live Q&A begins.

Materials

(Listed quantity is for 10 groups of 2-3 students)

- Student Worksheets (one per student)
- 2 bags of All-Purpose Flour (10kg)
- 1 large box of Cocoa powder or hot chocolate mix
- 10 Aluminum/Plastic Pans (kitty litter pans work well)
- 15 Impactors/Balls (variety of sizes and shapes)
    - *Depending on what students choose to vary, using Styrofoam balls or making balls from clay or Play-Doh work very well.*
    - *Students can be creative… consider changes in shape, angle, etc.*
    - *The teacher can provide these materials, or, students can be tasked with making/bringing their own.*
- 10 metre sticks (for measuring the drop height)
- 10 rulers (for measuring the diameter/depth of craters)
- 1 Sifter
- 1 weighing scale
- 2-3 Protractors (only required if the group is using angle as their independent variable)
- Tablecloths or tarps to protect the work surfaces (Optional)

Pre-event Setup

1. Fill each pan with ~10cm of white flour.
2. Without compressing the flour much, smooth the flour using a block or piece of cardboard to make the surface flat.
3. Using a sieve/sifter, uniformly dust the surface of the flour with ~2mm of cocoa, hot chocolate mix, or some sort of dark powder.
4. You can use tarps or table clothes under the pans to protect the work surface and the floor from flour/cocoa powder. (Optional)

Pre-event Discussion

- If students have not learned about inquiry/experimental design (i.e. independent & dependent variables), go over the concepts with them before this activity. This will prepare them for brainstorming the variables and designing their experiment during this event.
    - It is important for students to understand that they may only test changes in *one* independent variable. Explain that if they made changes to the drop height *and* impactor mass, for example, they would be unable to tell whether the observed changes in crater depth (or diameter) were due to height change, or mass change.
- Together with your students, go over the plan for the event as well as the worksheet as a class.

During the event

- Have the students sketch a cross section of a crater and label the features, based on what they learned during the presentation (see Figure 1 below).

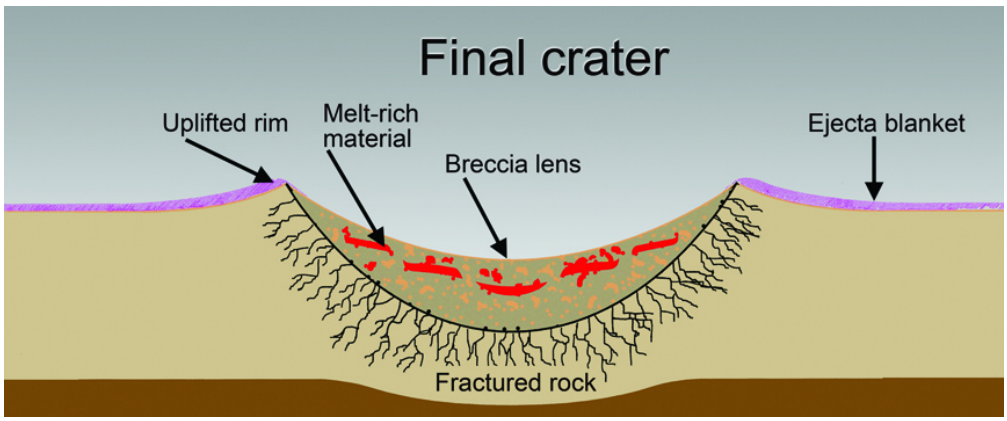


Figure 1: Crater cross-sectional diagram

- Brainstorm possible independent and dependent variables with the students. Have each group choose one independent variable to manipulate and one dependent variable to measure.
- Each student should write an "If… then…" hypothesis statement.
    - For example, "If the impactor mass increases, then the crater depth will increase."
- Before each group moves on to performing their experiment, check their experimental design to make sure the proposed experiment is reasonable and possible given your resources.
- If a pan needs to be resurfaced, just mix the cocoa into the flour, smooth, and dust the top with more cocoa power.
    - Students with ray-lengths as their dependent variable may want to smooth and re-surface their tray between each trial, so that they can drop into the middle without having the sides of the tray interfere with the rays.
- Students can also make basic qualitative observations of the other possible dependent variables that were not part of the main experiment.
    - For example, if students are measuring changes in crater diameter with changing drop heights, did the crater depth and ray lengths also seem to change? How?

Wrap-up

- Keep the flour afterwards! The flour-cocoa mix can be stored in a bin and used for future labs until the flour is too dark (from cocoa inclusion) to recognize the rays on the surface.

- Once all trials are done and the lab space is cleaned up, students can:
  - Graph their results,
  - Complete the follow-up questions on their worksheets, and
  - Write their conclusions.
- You can end this activity with the students handing in their worksheets/reports, but it is also beneficial to have the students share their results with the rest of the class.
  - Make a table on the board where students write their group name, independent and dependent variable, and a brief explanation of their findings (e.g. increased mass leads to deeper craters).
  - If this is done before students write their conclusions, then students can comment on the findings of all the groups and note these trends in their lab.

Extra Notes, Recommendations and Alternate Approaches

- Common experiments:

Independent Variable	Dependent Variable
Drop Height	Crater Depth
Drop Height	Crater Diameter
Drop Height	Ejecta ray Length
Impactor Mass	Crater Depth
Impactor Mass	Crater Diameter
Impactor Mass	Ejecta ray Length
Impactor Diameter	Crater Depth
Impactor Diameter	Crater Diameter
Impactor Diameter	Ejecta ray Length

- Alternative Experiments:

Independent Variable	Dependent Variable
Angle of Impact†	Crater Diameter
Angle of Impact†	Ejecta ray Length
Impact Material*	Crater Depth
Impact Material*	Crater Diameter
Impact Material*	Ejecta ray Length

† To change the angle of impact, we have used a nerf-ball gun and a chalkboard-sized protractor. When measuring crater diameter, student can measure both the long and short axis, or choose one. More simply, student can tip their tray and use a protractor to determine the angle of impact.

* E.g. sand, soil, etc. For dark impact materials, dust flour (not cocoa) on the surface so the rays are visible.

An extended version of the presentation & worksheet are available on the Centre for Planetary Science and Exploration (CPSX) website: cpsx.uwo.ca/outreach. The presentation and worksheet can be used to further extend learning on impact cratering processes.