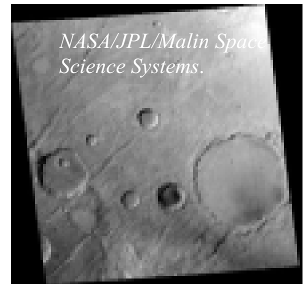
Impact Craters

Lesson 2 – Using Craters to Determine Relative Ages of Planetary Surfaces

USGS science for a changing world
Astrogeology Research Program



Using Craters to Determine Relative Ages of Planetary Surfaces

Grade Level: 7-12

Objectives:

- Creation of a model of a cratered planetary surface.
- Comparison of various models.
- Categorize planetary surface by relative age.
- Determination of the relative age of planetary surfaces using spacecraft imagery.
- Work in cooperative groups to perform an experiment and evaluate the results.
- Knowledge of associated vocabulary terms.

Arizona State Standards:

- **6SC-P4. PO 1.** Provide evidence for change in Earth's geologic history, using data from relative dating techniques.
- **1SC-P2.** Compare observations of the real world to observations of a constructed model (e.g., an aquarium, a terrarium, a volcano). **PO 1**. Assess the capability of a model to represent a "real world" scenario.

Background:

Show Overhead 1containing images of planetary surfaces.

Q: What do you notice about these images?

Possible Answer: They all have craters.

Q: What are these images of?

Q: Describe the craters (size, quantity, degradation state, morphology).

Q: Is the Earth included in this image set? Which image or images? Point out which image is of the Earth (Meteor Crater). Tell students what other planetary surfaces are shown (refer to key for Overhead 1).

Craters are results of an impact with an extraterrestrial object such as an asteroid or comet with the Earth's surface. The size and shape of a crater depends on the physical properties of the impactor such as material, mass, velocity and angle of impact.

Explain that observing superposed impact structures can **relatively date** planetary surfaces. By observing crosscutting relationships and layering, relative dates are determined. Usually, wherever units or layers are exposed, it can be assumed that the bottom layer was deposited first and is therefore the oldest. This sequencing continues up to the topmost unit which would be the youngest. An actual geologic age cannot be determined in this way; only that one unit is 'relatively' younger than another. Concepts that can be introduced here include:

- If one surface has more craters than another surface, the surface with the most craters is older. For example, when analyzing two surfaces, A and

B, where surface A has 10 craters and surface B has 100 craters, it can be concluded that Surface B is older.
- Over time craters erode. The more degraded a crater is (smoothed, **mantled**, or filled in with a flat floor) the older the crater.
- If one crater is inside another crater, the outside crater is older.
- Some craters, especially those on the moon, have bright rays. These rays will cover older craters, but brightness will degrade with time.
- Sometimes all that is left of a crater is a circular band of hills. This means that the crater's original depression was filled in by some material such as lava, sand, or sediment. These craters are commonly older than their surroundings.

Lesson Overview:
To illustrate how the surfaces of many planets are modified by impacts and demonstrate how craters can be used to relatively date different surfaces.

Materials:
Each student group of four will need:
- 3 bowls or small tubs (provided)
- flour
- cocoa
- a packet of different size and mass round objects (There should be more small objects than large ones in each packet) (provided)
- a stop watch

Procedure:
Groups of four should fill tubs half full with flour and sprinkle a layer of cocoa over the top. One student will drop round objects into tubs, one will be the timer, one will be the recorder, and one will count craters.

- Students will do three trials allowing different time intervals for cratering.
  - In the first trial objects will be dropped into the tub for 20 seconds.
  - In the second trial objects will be dropped for 1 minute.
  - In the third trial objects will be dropped for 3 minutes.
- Have the students observe the results from each trial with the following questions in mind:
  - How do the craters sizes vary?
  - What happened to the larger crater?
  - Which dish has the most small craters?
  - How can older craters be distinguished from younger craters?
- Students will draw schematics of their tubs on whiteboards and gather data about the number and sizes of the craters formed. They will create a table from their data and graph their results.

Assessment:
Have the students switch lab tables and observe another group's tubs. Have them put the tubs in order from the youngest surface to the oldest surface. Make sure they support their answers with data using knowledge gained from the first part of the lesson. Students can also be assessed on the accuracy of their visuals.

Closure:
Close the lesson with a discussion about how craters are used to date surfaces (Overhead 2). Ask why there are not as many craters on Earth as on other planets?
Show map of terrestrial craters (Overhead 3).

Q: Why does Earth have fewer craters?

Possible Answers:

- Earth is younger than other planets.
- Craters have eroded away.
- Meteors hit water or ocean.
- **Plate tectonics** has recycled the Earth's crust.
- Earth wasn't in a **meteors** path, fewer hit Earth.

Q: Where are craters located?

- Groups
- Clusters
- Oceans

Begin a discussion relating the small number of craters on Earth to the many found on other planets. Allow the students to contribute much of the information. Introduce appropriate vocabulary words.

Homework:
Hand out the both the Relative Ages of Planetary Surfaces and Relative Ages of Impact Craters and Martian Fretted Channel activities for homework. These exercises will integrate the concept of relative surface age with the analysis of relative ages of distinct geologic features such as impact craters and channels (Overheads 4 and 5, including keys).

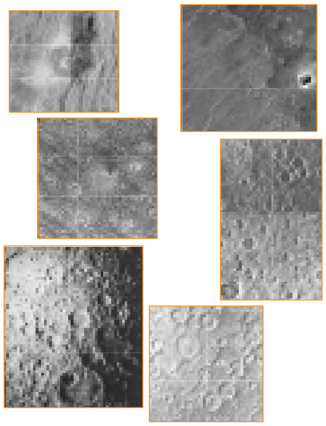
Vocabulary:
Relative dating, ejecta, degradation, mantled, mass wasting, plate tectonics meteors

References and Resources (see also list at end of Introduction):

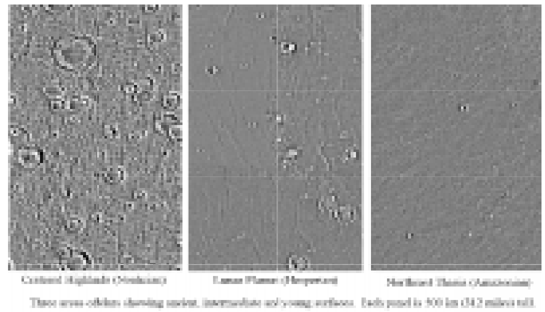
* Activities in Planetary Geology for Physical and Earth Sciences, **Impact Cratering on a Rainy Day,** NASA EG-1998-03-109-HQ. (provided)

* Malin, M.C., Edgett, K.S., Davis, S.D., Caplinger, M.A., Jensen, E., Supulver, K.D., and Sandoval, J. [Image M1201820], Malin Space Science Systems Mars Orbiter Camera Image Gallery (http://www.msss.com/moc_gallery), [October 16, 2000].

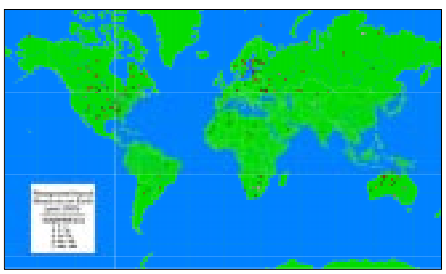
OVERHEADS



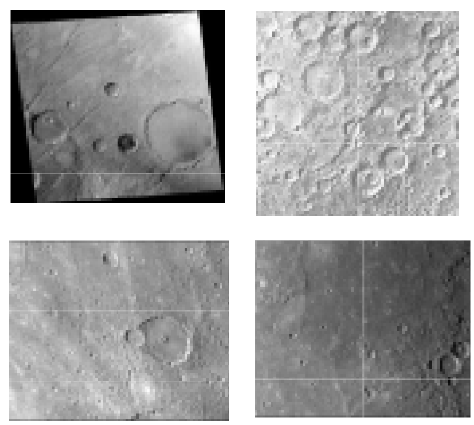
Overhead 1. Craters around the Solar System. (includes key)



Overhead 2. Impact craters showing relative surface ages on Mars.



Overhead 3. Map of terrestrial craters.



Overhead 4. Relative ages of planetary surfaces activi ty. (includes key)

Overhead 5. Relative ages of impact craters and fretted channels activity. (includes key)