



Are All Asteroids' Surfaces The Same Age?

Middle/high school grades

Lesson Summary

Students count craters on images of the asteroids Gaspra and Ida to determine the asteroids' ages.

Prior Knowledge & Skills

- Characteristics of asteroids

AAAS Science Benchmarks

The Physical Setting

The Universe

The Nature of Science

Scientific Inquiry

NSES Science Standards

- **Earth and space science:** Earth in the Solar System (5-8), Origin and evolution of the earth system (9-12)
- **Science as inquiry:** Abilities necessary to do scientific inquiry, Understanding about scientific inquiry

NCTM Mathematics Standards

(If constructing a map scale.)

- **Measurement:** Apply appropriate techniques, tools, and formulas to determine measurements

Teaching Time: One 45-minute period

Materials

To share with the whole class:

- Slides or overhead transparencies of Gaspra and Ida images
- Large piece of butcher paper (optional)

Advanced Planning

Preparation Time: 30 minutes

1. Draw grid lines on butcher paper or white board
2. Review lesson plan

Why Do We Care?

One of the fundamental tools for determining the geologic history of our solar system is through bombardment patterns. Asteroids are chunks of rock and debris leftover from the formation of the planets. Asteroids formed at the same time as the rest of the solar system, about 4.6 billion years ago. Most asteroids occupy a region between Jupiter and Mars known as the asteroid belt. As asteroids travel, they bump other asteroids. A small collision leaves behind craters on the asteroid's surface, while bigger a collision can break an asteroid into pieces. When an asteroid breaks up, a fresh surface is revealed. This young surface has been protected from cratering. Observing the craters on an asteroid's surface can tell us about its age and its history.

Source: *Galileo K-12 Educator's Resources, Project Galileo, NASA/JPL*

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Resource used: Images from Educator's Slide Set, attached, or available at <http://www2.jpl.nasa.gov/galileo/slides/>

Background: Asteroids may well crash and bump into each other. They may fracture into smaller bodies. Or they may get lucky and continue, unmolested, along their orbits. Can we find any differences in Galileo's flyby images of Gaspra and Ida that would suggest they are different ages? (answer as of July 1995: preliminary evidence is that Ida's surface is older, but scientists are still checking data that will tell them what the surfaces of the two asteroids are made of, which may modify the answer).

Activity description:

1. Tape up a large piece (5' x 3' piece of butcher paper, for example) of paper with big grid marks. Or, draw a grid on a white board.
2. Project the slides of Gaspra and Ida (to project these at the same scale, put the slide projector about 3 times further away when projecting the Ida slide (you can also have your students work this out, given the true sizes of Gaspra and Ida). Putting the projector at roughly 18 feet from the screen, I could use 5" x 5" squares to represent 5 x 5 kilometer areas. At the edges, as the asteroid curves away, each square will end up covering much more area (foreshortening), so you may want to ignore these areas.
3. Assign two or three students to count the craters in one or two squares. An easy way to count is to circle each crater after it's been counted. Use a different color marker for each asteroid.
4. Think a little about how we make these counts: do all the students agree on what is and on what isn't a crater (it's not always easy to tell!)? How would scientists make sure that something is or isn't a crater?

Easier level activities:

- Calculate the average number of craters per square (or per square kilometer, if your students have made up a scale for the image) for each asteroid. Which asteroid (if either) has more? Should an older asteroid have a higher or lower crater density? Why? How is this like counting scratches on two different cars (both driven by the same person)? Or, like scratches on glasses lenses? Dents on bicycles? Folds on dollar bills?
- How big is the biggest crater you can see on Gaspra? on Ida? (easier--are

- the biggest craters on both asteroids the same size?)
- How big is the smallest crater that you can see on Gaspra? on Ida? Is there a difference between the two? If you can see smaller craters on one asteroid, why would it be so?
 - What is the crater density per square (or per square kilometer) on each asteroid (watch out for foreshortening!)?
 - Are the crater edges "crisp" or "weathered?" Which type is older, assuming that there's no change in the material that they're made of?
 - Are there craters that have other craters on top of them? How does this happen? Do you see these on both Gaspra and Ida?

More advanced:

- Given that Gaspra is 17 kilometers (10 miles) long by 10 kilometers (6 miles) wide, and Ida is 58 kilometers (35 miles) long and 23 kilometers (14 miles) wide, construct a map scale (e.g. 2.5 cm = 1 km).
- Which direction is the Sun coming from in each image? How can you tell? Is it easier to count craters when the Sun's light is shining directly onto the surface, or when the Sun's light is coming at an angle? Why?
- "Bin" the data: how many craters can you count on each asteroid that are at least as big as the bottom of a dixie cup? as a quarter? as a dime? Calculate the average density of large craters per square kilometer, or quarter-sized craters per square kilometer. Do these vary between the two asteroids?
- Do you see any "pairs" of craters that look like they're about the same age? Scientists think that these craters may possibly be due to a string of impacts akin to the Comet Shoemaker-Levy/9 comet impacts with Jupiter, where a rain of impacts leaves behind a chain of craters.



Asteroid Ida



Asteroid Gaspra