Ages:
Grades 8 - HS

Duration:
45 minutes

Materials:
For each group of 3-5 students
- Photo of Apollo 15 landing site
- Plastic overlay
- Key concepts

For each student
- Student worksheet

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Geologic Mapping of the Moon

Overview —

The students will use analyze a photograph of the Apollo 15 landing site on the Moon to determine the relative ages of various features on the Moon.

Objective —

The students will:
- Examine and analyze a photograph of the Moon's surface
- Demonstrate their understanding of the geological tool of superposition to determine relative ages of features

Before You Start: *The students should be familiar with some basic terms: crater, mare, highlands, and trough.*

Activity —

1. Invite the students to view the photograph that each group has been given. Ask them in general what types of regions can be seen? (*light and dark e.g. dark areas of the Moon are referred to as* ***mare*** *- latin for seas. Light areas are referred to as* ***highlands*** *or* ***terra*** *–latin for land).*
2. Ask the students to describe the direction of the Sun, by looking for the shadows.
3. Ask the students about the features they see—round craters, any channels, smooth versus rough areas, high versus low areas. Invite them to highlight the craters and channels on the plastic overlay using dotted lines.
4. Ask the students to describe what units they see on the photograph.
5. Invite the students to, trace the units' contact (boundary between different units) using a thin, solid line on the plastic overlay.
6. Have the students work on the questions in the student worksheet, either individually or in groups.

Ties to Standards —

National Science Education Standards, Grades 9-12
Science as Inquiry - Content Standard A
Recognize and Analyze Alterative Explanations and Models.
This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.

Earth and Space Science - Content Standard D
The Origin and Evolution of the Earth System
Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Current methods include using the known decay rates of radioactive isotopes present in rocks to measure the time since the rock was formed.

Texas Essential Knowledge and Skills:
Earth and Space Science
(7) Earth in space and time. The student knows that scientific dating methods of fossils and rock sequences are used to construct a chronology of Earth's history expressed in the geologic time scale. The student is expected to:
(A) evaluate relative dating methods using original horizontality, rock superposition, lateral continuity, cross-cutting relationships, unconformities, index fossils, and biozones based on fossil succession to determine chronological order.

Student Worksheet

Examine the Apollo 15 image and the units you can see.

Answer the questions below.

1. There are a number of indicators of whether one unit is superposed (on top of) on another unit. One of these indicators is called an **embayment relation**. This occurs when a unit is deposited in fluid form, for instance as lava flows or as sediment that settled out of water. In this case <u>the younger unit embays the older unit</u>, or in other words, it <u>fills in low spots of the older unit at the contact</u>. When one feature embays another it often looks like the water of a bay flowing around land features, and this is where the term **embay** comes from. Look carefully at the contact between the mare and terra for an embayment relation. On this basis, which unit (mare or terra) is younger? Why?

   ____

   ____

2. Now look at the number of craters on each of the two units. Do the crater densities show the same relative ages of the mare and highlands as you just determined? If not, can you think of a possible reason why?

   ____

   ____

3. The major structure in this photograph is the curvy trough, called Hadley Rille. Trace it on the plastic overlay. What would you call this structure?

   ____

4. What are the relative ages of the mare and Hadley Rille? What principle did you use to recognize this age relation?

   ____

   ____

5. Look at the large, round impact crater alongside Hadley Rille. This is Hadley crater. What are the relative ages of Hadley crater and Hadley Rille? Why?

   ____

   ____

6. Now, reconstruct the geologic history of the area surrounding Hadley Rille by numbering the following units and structures in the order in which they formed (unit 1 formed first).

   ______Hadley crater

   ______Mare

   ______Highlands

   ______ Hadley Rille

7. Based on everything you've learned about the mare, what kind of rock do you think it might be (lava flows, sediments, coal, etc.) What is necessary for you to know for sure?

   ____

   ____

8. Look at the slightly brighter region of mare away from the contact with the highlands (terra). This region contains an abundance of very small craters with noncircular shapes. Compare and contrast their appearance (their size, shape, and relief) with that of Hadley crater, by listing their similarities and differences.

Similarities	Differences
___________________________________	_________________________________
___________________________________	_________________________________
___________________________________	_________________________________
___________________________________	_________________________________

9. Are these unusual craters older or younger than the mare? Why?

   ____

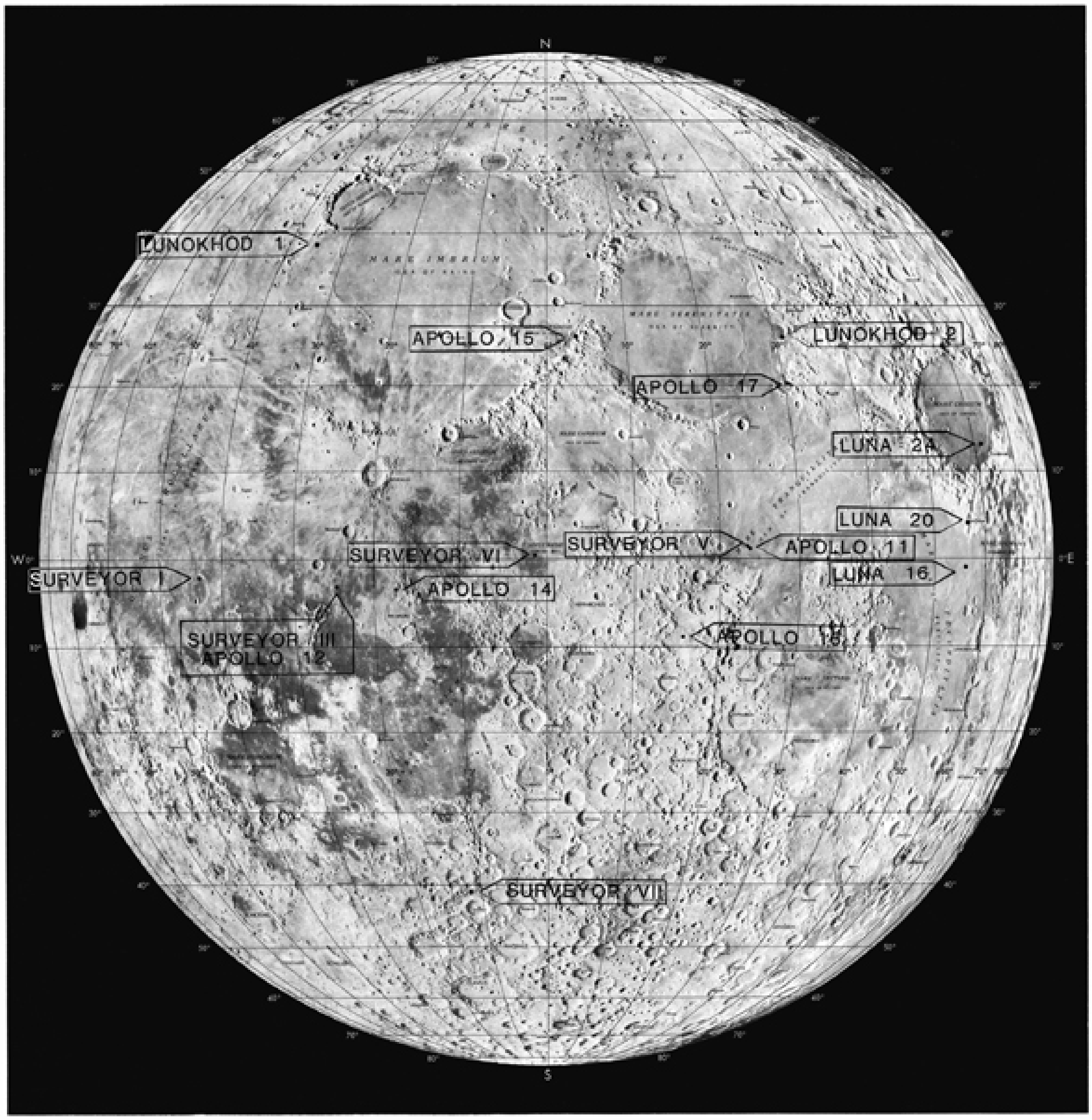
   ____

10. How might the origin of the unusual craters have differed from the origin of Hadley crater? Can you think of a process that could have formed them?

   ____

   ____

LUNAR LANDING SITE CHART



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LEM-1A
LUNAR EARTHSIDE HEMISPHERE
USAF LUNAR REFERENCE MOSAIC

Apollo 15 Landing Site

Geologic Mapping and the Geology of the Moon

Key Concepts

Geologic unit - A group of rocks with the same definite characteristics. A geologic unit is shown on a geologic map with a particular color.

Contact - The boundary between different geologic units, shown on a geologic map as a thin, solid line.

Structures - Physical features that affect the shapes of geologic units, such as channels and faults..

> **Channel** - A narrow, winding depression generally carved by flowing liquid like water or lava. A channel is shown on a geologic map using a dash-dot line.
>
> **Fault** - A large break in a planet's crust, across which the crust has moved. It is shown on a geologic map as a heavy, solid line.

Geologic map - A map showing surface geologic units of a region and important geologic features like faults, folds, and channels.

Relative age - The age of a geologic unit or structure relative to another geologic unit or structure. The unit or structure is "older than" or "younger than" another one.

Geologic history - The basic history of how the geologic units in an area were formed and what happened over time. Scientists use two principles to decode the geologic history of an area from an overhead photograph or a geologic map:

> **Principle of superposition** - Whatever unit lies on top of, or **superposes**, other units is the youngest unit. The bottom unit had to be there first in order for a younger unit to form on top.
>
> **Principle of cross-cutting relations** - Structures such as faults and channels which disrupt geologic units, are younger than the units they disrupt, or **cross-cut.**

Studying geology using pictures is called **photogeology**. It is different from studying geology on the ground, because all the observations are made from a distance.

Impact craters are circular, raised-rimmed depressions formed by explosions that occur when comets and asteroids collide with the Moon. Impact craters provide an important tool for determining the relative ages of different units: <u>Older units have more impact craters on them. and younger units have fewer impact craters</u>. The number of craters in an area of specified size is called **crater density;** thus, older units have a higher crater density than younger units.