Finding Mars on Earth:
Using Earth Analogs to Understand the Red Planet

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Abstract

In this activity, students will use photos and Google Earth to compare and contract analogous Mars and Earth features, deciding which geological processes have been at work to create the landforms. This activity is appropriate for Earth Science and Geology classes.

National Standards

This activity meets the following national science standards:

Evidence, Models, and Explanation (a) Evidence - observations and data on which to base scientific explanations; and (b) Explanations - making interpretations, meaning, or sense of observations.

Change, Constancy, and Measurement (a): Change - identify and measure changes in properties, positions, and forms of systems.

Form and Function (a): Students use form to explain function.

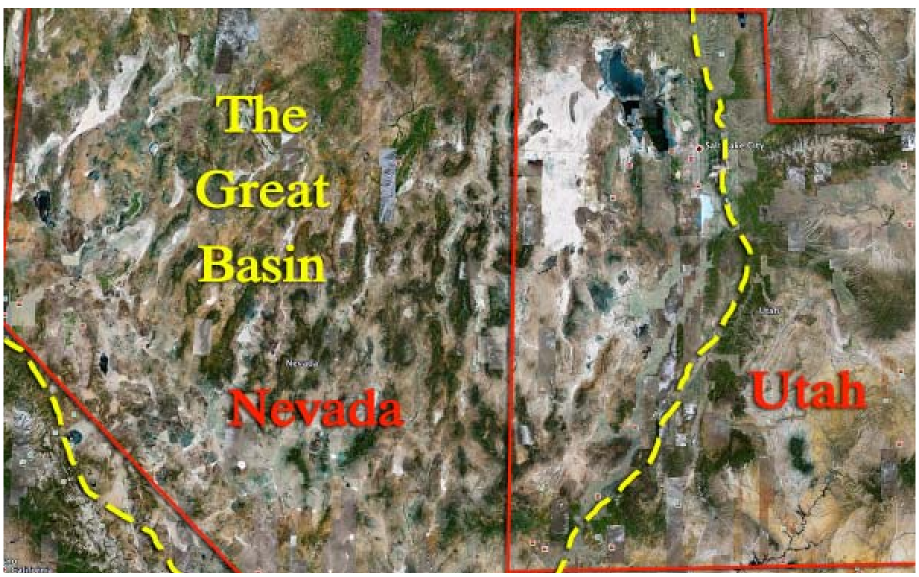
Abilities Necessary to do Scientific Inquiry (c): Use technology and mathematics to improve investigations and communication; and (f) Communicate and defend a scientific argument.

Background Information

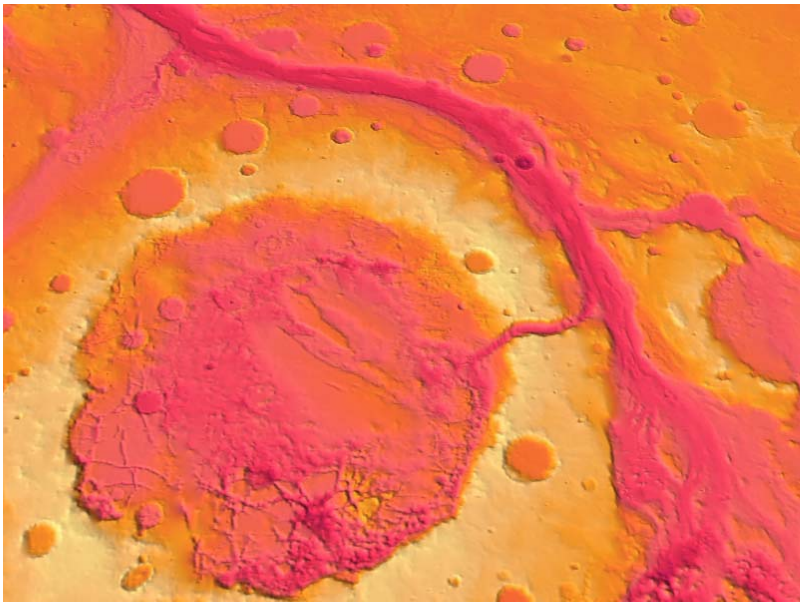
Complex ideas are sometimes easier to understand if we can find a similar situation or related example that is closer to home. For example, to understand how planets outside our solar system are discovered using the Doppler shift method (the red and blue shift of the star indicates that a planet is tugging on it), we use an example that is more familiar to us: the sound of a train whistle as it passes. As the train approaches, its whistle has a higher pitch, and as it passes, the pitch lowers. This is similar to how light coming from a star works – when it is moving toward us, its light is shifted to higher frequencies (blue shifted) and when it is tugged away from us, its light is red shifted to lower frequencies. Of course, for a train, we're talking about sound and not light, so the situations aren't identical, but the similarities allow for useful comparisons. Such examples are known as ***analogies***, because they are analogous (similar) situations which model or simulate a more complex idea in some fundamental way.

In order to fully understand the complex geology of Mars, we would need to have teams of trained field geologists spread out on the surface with hammers and tools, taking samples for radiometric dating of the Martian rocks. Since that isn't likely to happen for some time yet, we have to settle for viewing Mars from orbit and from a few ground locations using robotic probes. We can understand the confusing jumble of terrains better if we compare them with Earth analogs – areas of Earth that are similar in some ways to areas of Mars. If similar types of landforms are seen, we can conclude that similar processes must be working on Mars.

To find good Earth analogs, we need to locate a region that has similar characteristics of climate and rock layers and that preferably isn't covered by annoying plant life (to a geologist, plants just get in the way of the rocks). On Mars, the target sites for the Mars Science Laboratory formed billions of years ago when Mars was warmer and wetter and had a thicker atmosphere. Yet even then, Mars' climate was arid, with little rainfall to create continuous rivers except perhaps a few catastrophic floods now and then. We don't see many well-integrated river channels or extensive headward erosion of tributaries on Mars as we do in wet climates on Earth, but we do see huge channels that carried massive amounts of water, similar to arroyos and slot canyons here. Therefore, we need to find similar areas on Earth: locations with an arid climate and little rainfall, with poorly integrated river channels except the occasion flash flood that would display the same patterns of erosion and deposition as Mars.



The deserts of the North American southwest, and especially the Great Basin of Nevada and western Utah, provide ideal analogs for Mars terrains. Walking through them, you almost can believe you are on Mars. I grew up in the desert of western Utah, and when I first saw the features of Mars in detail from our orbiting cameras, I didn't feel I was seeing an alien landscape at all; it looked very familiar. It looked like home. All of the features I was seeing were the same as I had grown up with: the playas, arroyos, alluvial fans, and sand dunes; the short meandering streams that disappear in the desert without ever reaching the ocean; in short, the Great Basin.



The Great Basin is a relatively recent feature of western Utah and Nevada, having formed within about the last 20 million years. As the wave of mountain building and volcanic activity that created the Rocky Mountains subsided, the western portion of North America collapsed to form a geographical basin. At the same time, the San Andreas Fault of California became active and as it pulled the western edge of California northward, it also stretched out this same area, leading to normal faulting and the sequence of basins and ranges that cross both states. Any water that runs off of these ranges winds up trapped in the valley basins, without an outlet to the ocean, and the basins become gradually more alkaline and salty. With the ending of the Pleistocene ice age and warming up of the climate, these basins have changed from large freshwater lakes to salty playas and dry hard pans, with any material washed out of the mountains abruptly depositing at the mouths of canyons to form steep-sloped alluvial fans, with deltas forming only at the ends of the few persistent streams. It's the most sparsely settled area of North America, and only geologists and the few of us who call it home would consider it beautiful.

Teacher Instructions

Objectives: At the conclusion of this lesson, students will be able to:

1 – Identify the similarities and differences between Mars landforms and Earth analogs.

2 – Recognize that the same processes that created the Earth landforms have also been at work on Mars to produce similar features.

3 – Provide evidence that liquid water not only flowed in rivers on Mars but also collected in lakes, depositing sediments that could hold signs of life.

4 – Define terms related to desert landforms and geological processes, such as alluvial fan, playa lake, river meander, desert pavement, etc.

Materials

Electronic copies of the student PDF file for each student team (the Student Worksheet), a general map of the Earth, a map of Mars (both showing latitude and longitude lines), Internet access, and Google Earth installed on a computer for each team.

Class Lead-In

Ask students if they know what an ***analog*** is. If any student does know, have that student explain what it means (Definition: using a similar, easier to understand example to represent an aspect of a concept or idea). Then provide several examples yourself. These can include the following or others:

1 – Using a train whistle to explain how the light from stars can be red shifted or blue shifted.

2 – Using the patterns of sea ice in the Arctic Ocean to explain the features seen on Jupiter's moon, Europa.

Explain that in this activity, student teams will try to decipher how landforms on Mars formed based on Earth analogs. Through research, they will discover how various Earth features formed, then compare the landforms with Martian equivalents to see if similar processes have been at work there. Since Mars is a cold, dry, desert planet, we will compare it to a similar location here: the American southwest and Great Basin of Utah and Nevada.

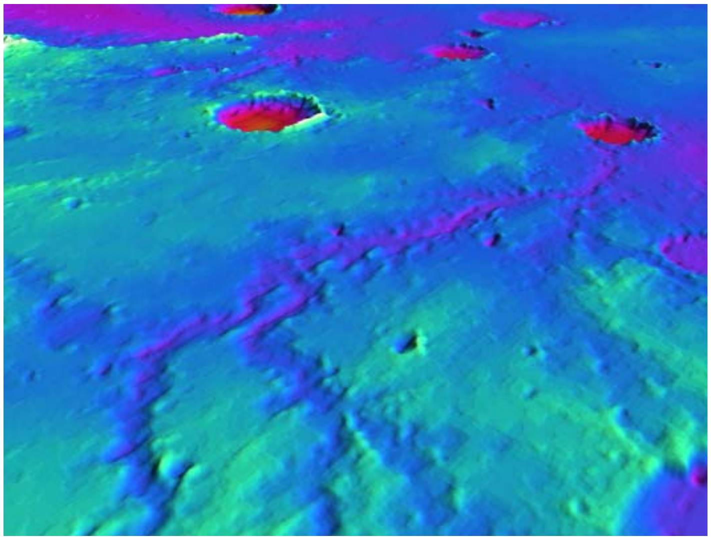
Point out the location of the Great Basin on your Earth map and explain how it formed (see the introduction above). Explain that the Great Basin and other parts of southwest North America show similar features to Mars and therefore probably formed in similar ways. The climate in the Great Basin is comparable to the climate on early Mars, when most of the features we will be studying formed.

In the PDF files given to each student, they will be asked to look up definitions of the following landforms and identify their features and the processes that form them.

Landforms and Processes

Landforms include: amphitheater, alluvial fan, landslide, arroyo, plateaus and mesas, river meander, river delta, playa lake (mud flat or hard pan), land-locked lake, salt flat, wave-cut terrace (bench), outflow channel, sand dunes, and impact crater.

Definitions and diagrams for the processes involved are given to the students in the Student Worksheet, which include: gravity, water erosion, headward erosion, frost heaving, talus slope, mass wasting, water transportation, deposition by water, wind erosion, and deposition by wind.



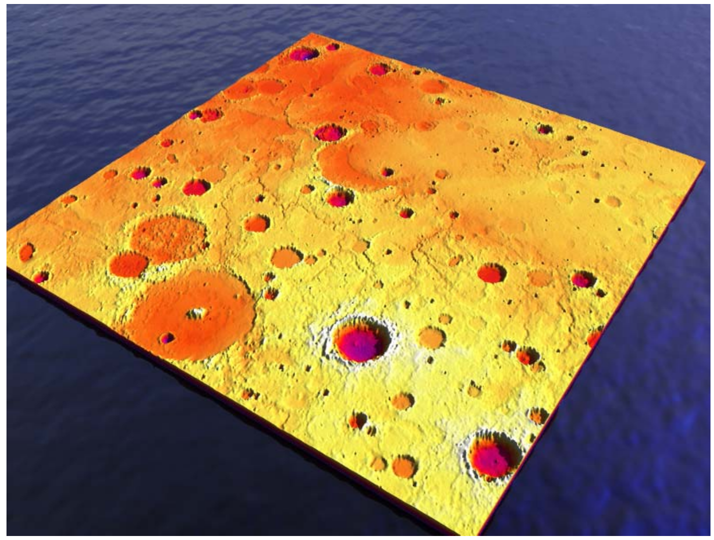
In the student worksheet, they are given an example of what they could write for amphitheaters. For the other landforms, they will need to look up a description of the landform and identify the processes at work and how they led to the landform's formation. Each landform also has accompanying photos showing examples from Earth and from Mars, as well as precise latitude and longitude coordinates so they can look up these features in Google Earth.

Using Google Earth

To use Google Earth, open the program while being connected to the Internet and choose "View – Explore" to pick Earth or Mars. Type in the latitude and longitude in the "Fly to" search bar in the upper left corner, and the program will zoom in to that location. You can use the navigation controls in the upper right corner to zoom in and out, move north, south, east, or west, or use the trackball control at the top to rotate the camera's view to a more oblique angle instead of looking directly down from overhead. You can also use a mouse or computer trackpad to move around and scroll in and out of the scene. A few minutes of experimenting will familiarize yourself and your students with the program.

Completing the Activity

Once the students have researched the causes and features of each landform, they will be asked to answer questions and draw conclusions from the analogous Earth features to see if similar processes are occurring on Mars.



To follow up on this activity, you can ask your students to contrast as well as compare Earth and Mars features. Although there are many analogies, there are also some unique features on Mars that are found nowhere on Earth, and vice versa. Have your students use Google Earth and maps of Earth and Mars to identify unique features (for example, large impact structures such as Hellas Basin with large volcanic plateaus [Tharsis Plateau] at the antipodes] and speculate as to how such features may have formed, doing additional research on the Internet. In the case of Hellas Basin and Tharsis Plateau, it appears that a large impact blasted out the Hellas Basin (and possibly deprived Mars of much of its atmosphere) and sent shockwaves through Mars, causing the Tharsis Plateau to bulge out on the opposite side along with huge shield volcanoes. A similar relationship appears to exist between Argyre Planitia and Elysium Mons. No similar relationships exist on Earth.

Earth also does not have any highly cratered terrain similar to Noachis Terra (at least not any more). Since other objects in the solar system show similar patterns of early heavy bombardment (including the Moon and Mercury), why don't we see it on Earth? Earth also has mid-ocean ridges and subduction zones that are not seen on Mars. Eventually this will lead to an understanding that whereas Mars is no longer tectonically active, Earth is and over time, Earth will recycle its geology faster than Mars.