

Mars Rock Density

Suggested Grade Level: 6–10

Summary

- Students will create their own “rock fields” using paper.
- Students will estimate percentages of rocks covering the surface in a given area.
- Students will compare their estimates with calculated percentages from measured values and compare their rock field with images of rock fields from Mars and New Mexico.

Standards

- NM Science Content Standards: Strand I, Scientific Thinking and Practice; Strand II, Standard III, Earth and Space Science NM Math Content Standards: Standards 3 and 5.
- National Science Education Standards: Middle School, Content Standards A, D, and G; High School, Content Standards A, E, and G.

Background Information

Geologists use estimates of rock population (density) and distribution when they are in the field in order to determine various geological processes (water deposition, volcanic lava flows, wind deposition) that have occurred at a particular site. Planetary geologists also use these estimates to attempt to understand the geologic history of the surfaces of other planets. It is also important to be able to predict the rock population in a given area in order to address safety concerns and the potential for science return for future mission landing sites.

Included in this activity are four images taken by the Mars Exploration Rover mission. These rock fields were imaged by the rover Spirit at three different sites during its trek across the lava plains surface of Gusev Crater and therefore represent a typical Mars volcanic lava rock density or population. For comparison, there is one photo taken of a rock field on the flank of an eroded volcano (Mt. Taylor) in New Mexico. You can use these images as real examples of rock field density when you teach this lesson.

Teachers will need to know how to calculate the percentages from measured areas and to lead their students through the mathematics. An easy way to calculate the rock population or the percentage of the surface covered by rocks is the following formula, with the paper areas expressed in square inches and a standard 8.5”x11” sheet measuring 93.5 square inches: the small area of white/gray paper selected by students to represent rocks divided by the area of whole sheet of red paper representing Mars surface, then multiply by 100 to equal the rock field density in percent.

Materials

1. Sheets of standard-sized paper, 8.5" X 11", white/gray color (to represent surface rocks)
2. Sheets of standard-sized paper, 8.5" X 11", red color (to represent background Mars surface soil or regolith)
3. One ruler
4. One pair of scissors
5. Glue sticks or white glue
6. Three images of Mars surface taken by the Mars Exploration Rover mission (included in this activity)
7. One photograph of the surface of a volcanic area in New Mexico (included in this activity)
8. Calculator (optional)
9. Pencil or Markers (optional)

Preparation

1. The primary materials are two sheets of paper, one sheet of white/gray color and one sheet of red color, for each student. Rulers, scissors, glue and calculator can be shared by groups of students.
2. Prior to teaching the activity, print out the Mars surface images and New Mexico photo included in this activity, in order to discuss differences in rock population in different areas.
3. After the activity, you may want to plan a short excursion to a nearby site that exhibits a rock population that can be compared to the simulated rock fields that the students will make. You can take your students to a natural site that has rocks on the surface, or you can use your own playground or school grounds and place rocks or boxes of different sizes. If you do not have rocks available or cannot go outdoors, you can use a variety of athletic equipment balls of different sizes scattered throughout a defined area in your gym or cafeteria.

Introduction for Students

Planetary landers or rovers take images of the surrounding surface and rocks on the surface. What can you do with images of rock fields? The appearance, size, and number of rocks can tell a geologist a lot about the geologic history and geologic processes that have affected the surface. The first piece of data to acquire is how much of the surface is actually covered by rocks. Each student will independently construct his/her own planetary rock field. Keep it secret and do not inform one another of your measured values.

Procedure

1. Each student will be issued one white/gray sheet of paper, one red sheet of paper, scissors, a ruler, a glue stick or white glue.
2. Each student will measure and outline an area of their choosing in square inches (or fractions) on the white paper and cut it out of the larger sheet. Any size area can be chosen. Care should be taken not to show others what the area is. Discard the remainder of the white or gray paper.
3. Secretly record the value of the area on the “back” of the red paper. If your area is a simple square or rectangle, the area will be easily calculated. If the area selected is an unusual shape, additional calculations will be needed.
4. Using the hands and NOT the scissors, each student should tear the white paper into a combination of large and small pieces to simulate rock shapes.
5. Glue the pieces of white/gray paper (simulated rocks) to the “front” of the red paper. Let dry.
6. Each student should secretly calculate the percentage of their own field by using the mathematical formula cited in Background Information, then write that percentage on the “back” of their completed simulated Mars rock field.
7. Collect the simulated rock fields.
8. Show each to the class and have them estimate the percentages.
9. Tell the correct field percentage then show the next, continue until they are capable of estimating within 10%.

Process/Closure

This activity can be easily linked to both mathematics and earth science. It is identical to the real geological analysis done on planetary surfaces. Show the class, or have class members collect surface images from Mars to examine and estimate the rock population percentage. For example, images from the landing sites of the two Viking Landers, Pathfinder, and the Mars Exploration Rovers (MER) could be compared with photographs from Earth or the Moon. Ask your students the following questions:

- “Could you do this out in the field using real rocks?”
- “Do you think that the rock percentage would be different for different types of geological terrain (arroyo, mesa, mountain foothills)?
- “Could you do this from a picture of rocks?”
- “How could you measure the area of rocks from a picture?”
- “If there was no scale given, how could you determine what units to use?”
- “Could you measure the density of other objects in this way?”
- “Could you measure clouds in the sky or minerals in a rock this way?” (In fact, differences in percentages of different minerals within a rock like granite are used by geologists to define different types of granitic rocks).

Extension/Enrichment

Using one or more locations near the school, have student teams (using tape, rope, plastic, a wooden frame, an old hula hoop) grid out areas somewhat free of vegetation. Then have them estimate, measure, and record rock population percentages. This is particularly useful if you can do the same activity in at least two different geological terrains. For example, choose from locations such as the surface of a lava flow, a dry riverbed or arroyo, granitic mountain foothills, or a sandstone mesa.

Take photographs of these locations then do the population analysis on the photographs in class, this will give students a sense of remote data gathering on other planets. Students can develop and use transparent (overlay) grid patterns to get more precise measurements.

Use the images taken by the MER rovers and the photo from New Mexico that are included in this activity and have your students calculate or estimate rock population at each site, this will give students practical geological experience in analysis of other planetary surfaces using images. Have your students compare the rock population on Mars with that of Mt. Taylor in New Mexico; are they similar? The MER images included in this activity and the photo of Mt. Taylor’s surface rocks are all believed to represent volcanic areas. Compare these rock populations with photographs of other geological locations on Earth and draw conclusions about the type of geological surface they are looking at on Mars. Although Earth

has experienced more erosion, the volcanism on Mars is probably older; these two processes probably balance out in affecting the rock population.

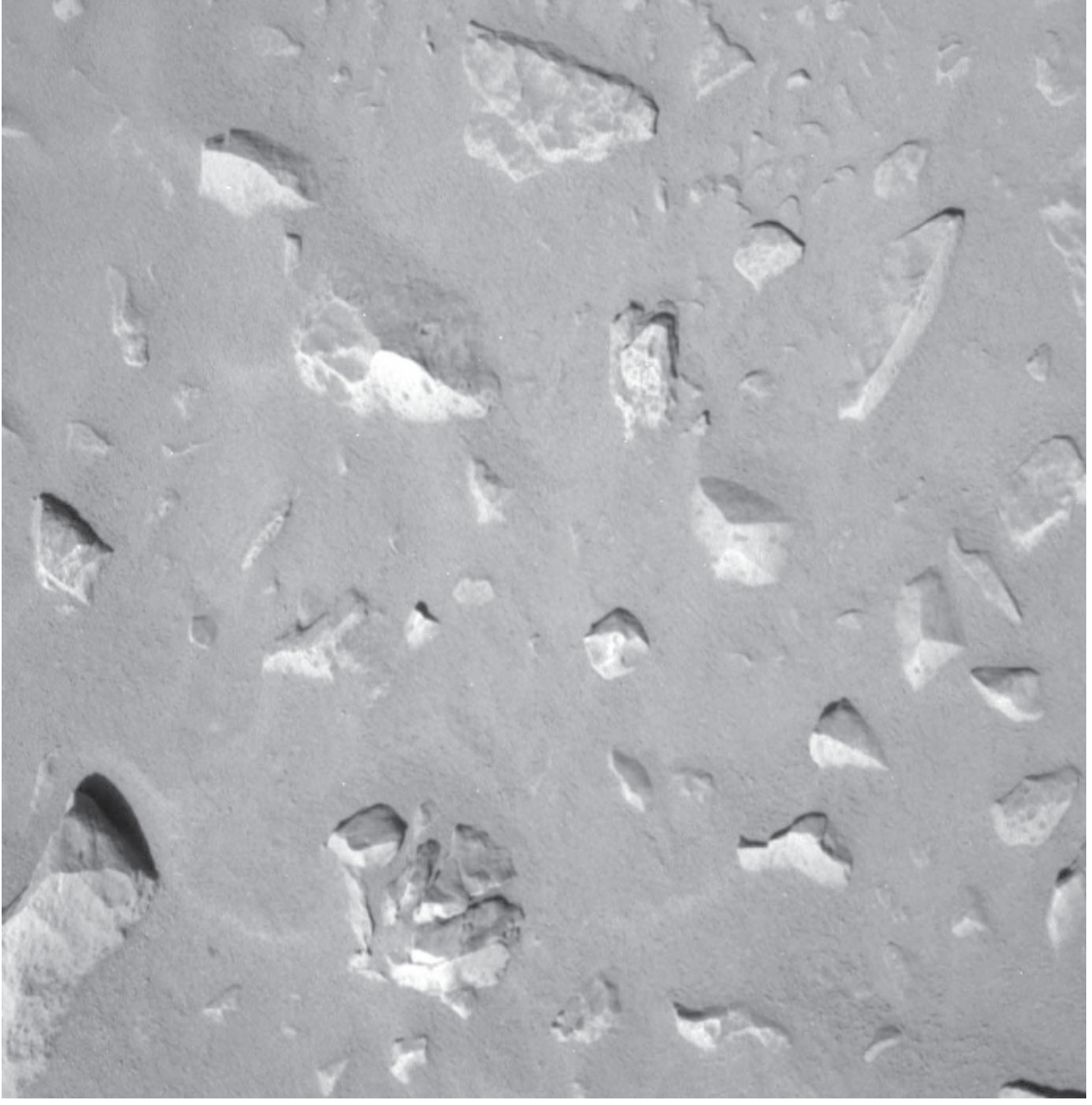
You have calculated the percentage of the surface covered by rocks. Now, extend the mathematics to size-frequency distribution of rocks. Measure each rock in the field of view and count and “bin” the number into size categories. Graph the number vs size categories to produce a size-frequency distribution. Compare various size-frequency distribution curves for different geological terrains. In general, most rock size-frequency distributions are exponential distributions.

Credits

This activity was created by Joseph Aragon, Laguna–Acoma High School, New Mexico.

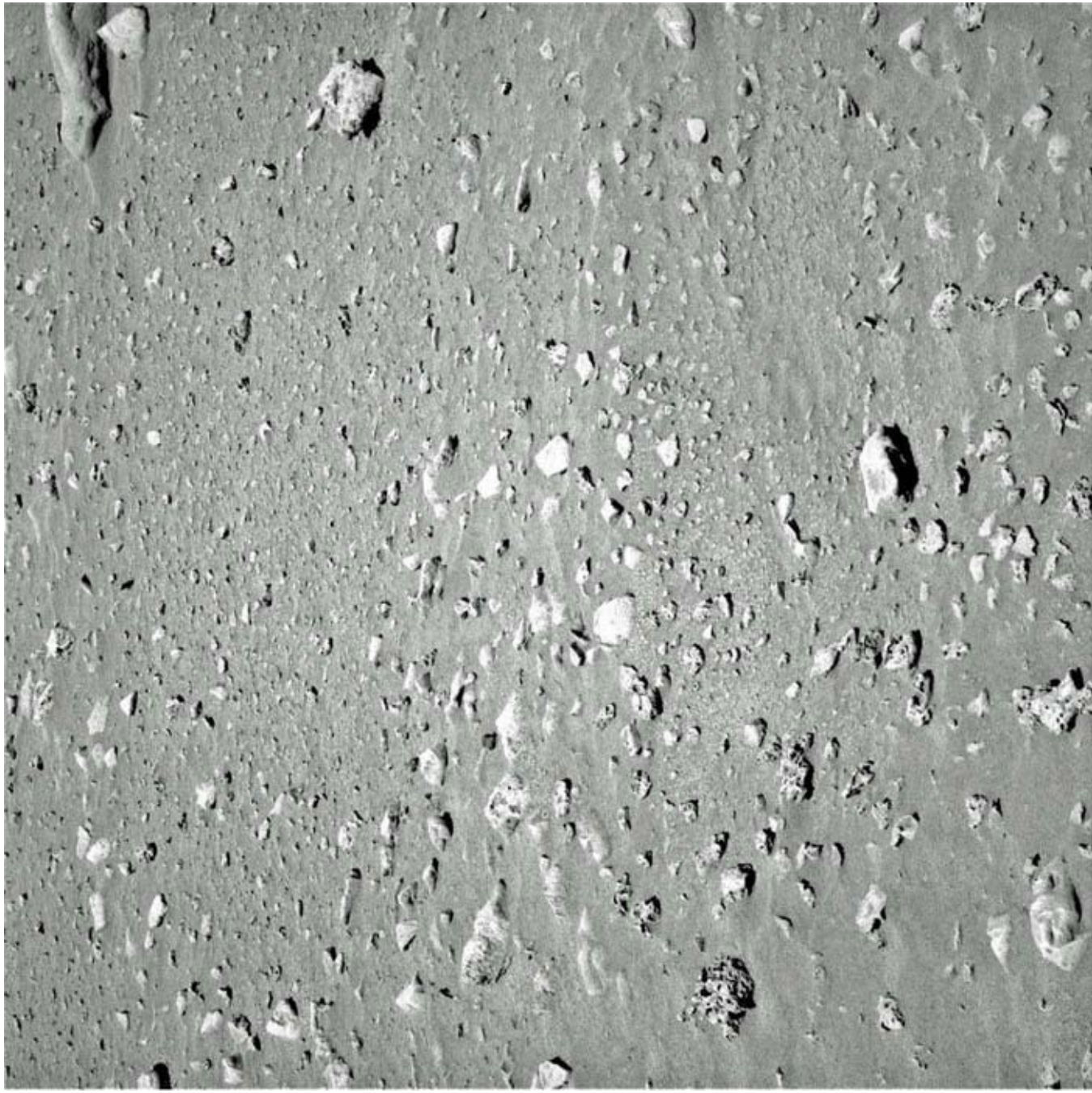


MER Image # 1 taken by the rover named Spirit on Sol (Mars Day) #62 showing an overview of an area of the surface of Mars. This image was taken during Spirit's trek from the landing site to the Columbia Hills

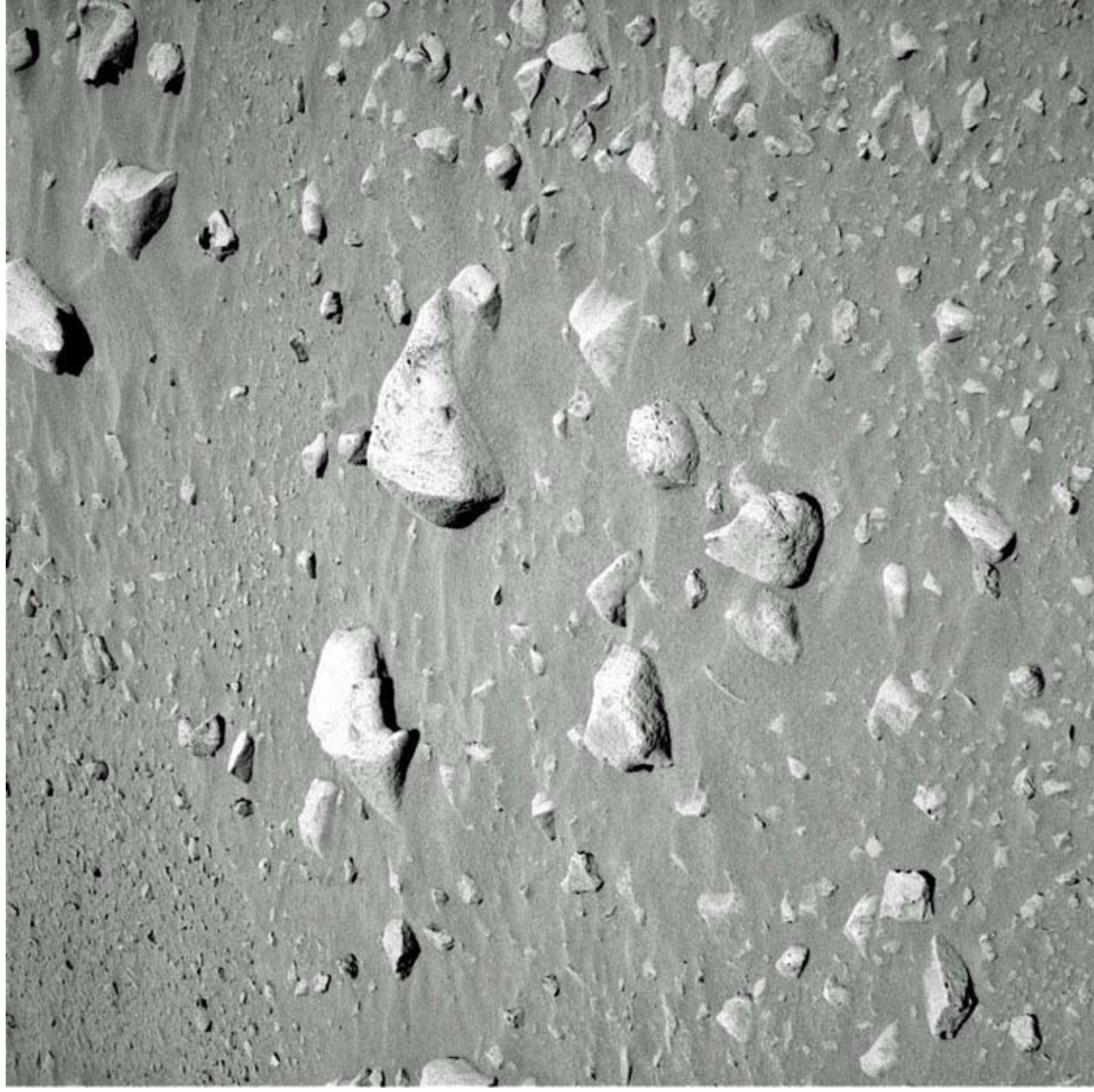


MER Image #2 taken by the rover named Spirit on Sol 62 showing a smaller area of rocks within the overview image (MER Image #1) taken on the same sol.

MER image #3 taken by the rover named Spirit on Sol 102 of an area of rocks on the surface of Mars. This image was taken during Spirit's trek toward the Columbia Hills



MER image #4 taken by the rover named Spirit on Sol 123 of an area of rocks on the surface of Mars. This image was taken during Spirit's continued trek toward the Columbia Hills





Photograph #5 taken by a geologist of the surface of a volcanic area in New Mexico.

This photo shows a typical rock population on the surface of the flanks of the volcano named Mt. Taylor located in western New Mexico.