Water on the Moon

Background

On March 5, 1998, it was announced that data returned by the Lunar Prospector spacecraft suggested water ice is present at both the north and south lunar poles. If these reports are confirmed, near-pure water ice may be present in discrete, confined deposits buried beneath as much as 18 inches (46 centimeters) of dry regolith. The discovery could open a number of interesting options for future explorations of space.

Because the Moon has no atmosphere, any substance on the lunar surface is exposed directly to the vacuum of space. Over the course of a lunar day (~29 Earth days), nearly all regions of the Moon are exposed to sunlight, and the temperature on the Moon in direct sunlight is high enough that water ice will rapidly sublime directly into water vapor and escape into space, as the Moon's low gravity cannot hold gas for any appreciable amount of time. Any ice exposed to sunlight for even a short time would be lost. The only possible way for ice to exist on the Moon would be in a permanently dark area, such as in the shadow of a crater.

The presence of water on the Moon could open up a number of valuable options for those who would endeavor to explore other planets. Because astronauts need to carry large quantities of water with them for their survival in space, great amounts of rocket fuel—which is typically expensive—are needed to overcome the force of Earth's gravity. Also, the elements that make up water (hydrogen and oxygen) can be used as rocket fuel itself. If water could be mined at the Moon's surface, where the force of gravity is only a fraction of what it is on Earth, large amounts of money could be saved. For example, manned missions could stop at the Moon before travelling to Mars or another distination. The resource might also be used to sustain a colony of people on the lunar surface.

Topic

Lunar Water

Objectives

Students will:

- Construct a solar water collector.
- Estimate the amount of water in a given sample of simulated lunar permafrost.

Overview

In this activity students will construct a solar water collector. Using the collector, students will collect and calculate the amount of water in an area of simulated lunar permafrost. Students will evaluate the pros and cons of using this system on the Moon.

Key Question

What obstacles do scientists face in attempting to extract water from lunar permafrost?

Key Concept

- Scientists must design and evaluate many ways of extracting water from the lunar permafrost before planning lunar colonies.

Materials & Preparation

- Cake pan or tray (approximately 9x12 inches, and at least 3 cm deep)
- Fine-grained sand, such as sandbox sand
- Plastic wrap
- Water
- Washers or pennies
- Access to a freezer
- Heat lamp
- Small paper cup
- Graduated cylinder
- Clock
- Tape

1. Prior to class put 600 ml of the sand into the pan. Pour 100 ml of water into the pan of sand. Prepare one pan for each group of

students. Place pans of sand into the freezer and leave until frozen solid.

2. Discuss with students the significance of finding water on the Moon. Think about how this water could be helpful, and allow them to start considering ways they might extract it.
3. Explain to the class that they will be making a scale model of a water extractor that might work well on the Moon.
4. Give each group of students a pan of simulated frozen lunar regolith and have the students place the paper cup in the center of the tray. If the cup is taller than the side of the tray, have the students trim the cup so that it sits about 2 cm lower than the side of the tray.
5. Have students seal the top of the tray with plastic wrap. Have them seal and secure the plastic wrap over the tray with tape so that, when weighted with the washers, it droops slightly. However, the plastic should not be so loose that it touches the rim of the cup. You may wish to walk around the class and ensure that the collectors are set up properly.
6. Students will then place the washers on top of the plastic directly above the cup.
7. Have students place the tray under the heat lamp and leave it there for at least 40 minutes. Make sure that they note the time they placed the tray under the lamp and record it on a separate sheet of paper. This will be their data sheet.
8. Have students go back after 40 minutes and dismantle their apparatus. Record how long the tray was under the lamp and measure the amount of water collected using the graduated cylinder.
9. Using the student worksheet, have students evaluate the pros and cons of using this type of solar water collector on the Moon.

Management

- Divide students into cooperative groups (small teams are preferred, but larger ones can be used if there are not enough materials to go around).
- One 50-minute class period

Reflection & Discussion

1. Building upon the questions they answered on their worksheets, discuss with students the pros and cons of a similar sun-powered device to retrieve lunar water. Some of them may include:

Pros:

- The simple design reduces the amount of materials that would need to be transported to the Moon.
- Solar energy is a resource that is readily available.
- A solar water collecting system would do little to no damage to the lunar surface.

Cons:

- While all latitudes and longitudes of the Moon receive sunlight, only half of the Moon receives sunlight at any given time.
- In the shadows of craters, where water is believed to exist, sunlight never touches the surface.
- The equatorial region of the Moon is a more convenient place to build a human habitat because it is more accessible.

Transfer/Extensions

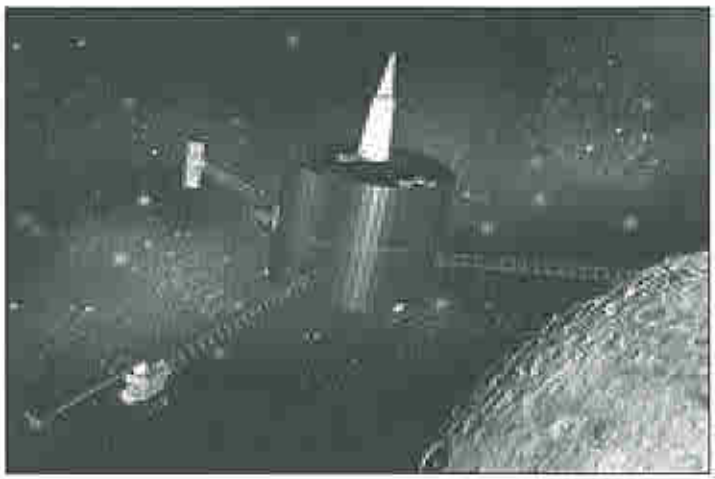
1. Design and test another method of extracting water from the simulated soil.
2. Research the methods NASA is considering for extracting water from the lunar surface.

STUDENT WORKSHEET

Water on the Moon

Student Procedures

1. Take a pan of simulated frozen lunar regolith and place the paper cup in the center of the tray. If the cup is taller than the side of the tray, trim the cup so that it sits about 2 cm lower than the side of the tray.
2. Seal the top of the tray with plastic wrap. Secure the plastic wrap over the tray with tape so that, when weighted with the washers, it droops slightly. However, the plastic should not be so loose that it touches the rim of the cup.
3. Place the washers on top of the plastic directly above the cup.
4. Place the tray under the heat lamp and leave it there for at least 40 minutes. Make sure that you note the time that you placed the tray under the lamp and record it on a separate sheet of paper. This will be your data sheet.
5. Go back after 40 minutes and dismantle your filter. Record how long the tray was under the lamp and measure the amount of water collected using the graduated cylinder.
6. Using the table below, evaluate the pros and cons of using this type of solar water collector on the Moon. You might consider such things as: the location of the unmined water; the topography of the Moon; ease of transportation; and environmental preservation. When you're finished, answer the Questions & Conclusions questions on a separate sheet of paper.



Lunar Prospector

Image courtesy of NASA

Pros of the solar collector

Cons of the solar collector

Questions & Conclusions:

1. How much water were you able to extract?
2. Consider how much water was collected and how long it took. Do you think this is an efficient method for collecting water? Explain.
3. Would you recommend this method to NASA? Why or why not?