MOON MINING

Activity topic selected from NASA's KSNN™ 21st Century Explorer newsbreak "Why return to the moon before going to Mars?"

Educator Section

Introduction

Many things were learned from the rock samples that the astronauts brought back with them from the moon during NASA's Apollo flights to the moon. What we learn on the moon will help us plan for crewed space missions to Mars, making it as safe and efficient as possible.

Lesson Objective

This lesson simulates the locating and the mining of ilmenite for oxygen on the moon.

Problem

How can I find and mine valuable resources from a simulated moon surface?

Learning Objectives

The students will

- gather data by spectroscopically locating the simulated ilmenite.
- collect simulated ilmenite by mining the simulated lunar surface.
- gather data by using observations while extracting oxygen from the simulated ilmenite over time.
- develop a conclusion based upon the results of this simulation.
- compare individual results to class results to look for patterns.

Materials

- NASA's KSNN™ 21st Century Explorer 30-second newsbreak, "Why return to the moon before going to Mars?" (Download the newsbreak at http://ksnn.larc.nasa.gov.)

Per group (2 students working together)

- 1 disposable plate moon
  - o 3 effervescent tablets
  - o ice
  - o white divided disposable plate (paper, plastic, or foam) with 3 or more sections

See how to make the disposable plate moon in the Pre-Lesson Instructions Section.

Grade Level: 3-5

Connections to Curriculum: Science

Science Process Skills: observing, classifying, measuring, inferring, predicting, communicating
(Association for the Advancement of Science)

Teacher Preparation Time: 30 minutes
(20 minutes the day before and 10 minutes the day of the lesson.)

Lesson Duration: 45 minutes

Prerequisite: none

National Education Standards addressed in this activity include Science (NSES), Mathematics (NCTM) and Geography (NCGE). For an alignment to standards in this activity, see page 5.

Materials Required

effervescent tablets

ice

white divided disposable plates

spoons

quart size, freezer, zipper seal bags

8.5" x 11" red transparencies

8.5" x 11" blue transparencies

centimeter rulers

safety glasses

graph paper (sample included)

stopwatches

NASA's KSNN™ 21st Century Explorer 30-second newsbreak – "Why return to the moon before going to Mars?"

- 1 - 8.5" x 11" red transparency
- 1 - 8.5" x 11" blue transparency
- 1 quart size, freezer, zipper seal bag
- 1 spoon
- centimeter ruler
- stopwatch, or timepiece with a second hand (watch or clock)

Per student

- safety glasses
- graph paper
- Moon Mining Student Section

Safety

Remind students about the importance of classroom and lab safety. Students should wear eye protection during this activity. Refer to MSDS sheets concerning effervescent tablets: http://www.msdssearch.com/msdssearch.htm. Use disposable latex-free gloves as necessary. This experiment will require proper clean up.

Pre-lesson Instructions

- Students should work in groups of 2.
- Identify a sunny location for the test site.
- Prepare the disposable plate moon: (at least one day before)
    - Crush three effervescent tablets and mix with enough crushed ice to fill in one section of a white, divided disposable plate. Work quickly so that the ice does not melt and activate the effervescent tablet.
    - Place only crushed ice into the other sections of the white, divided disposable plate.
    - Prepare and freeze one disposable plate per group.
    - Keep cold until students are ready to conduct the test procedure (this will ensure that the ice does not melt and activate the effervescent tablet).

Lesson Development

To prepare for this activity, the following background information is recommended:

- Read NASA's KSNN™ 21st Century Explorer Web Text Explanation titled "Why return to the moon before going to Mars?" at http://ksnn.larc.nasa.gov.
- The mineral ilmenite is Iron Titanium Oxide. You can read more about ilmenite here: http://mineral.galleries.com/minerals/oxides/ilmenite/ilmenite.htm. If the Internet is available to students in the classroom, visit this web site as part of the activity preparation. If the Internet is not available in the classroom, you may want to print this page and share it with your students.
- Read the following text taken from the Observation Section of the Moon Mining Student Section.

Observation

Many things were learned about the moon during the Apollo flights to the moon. Much of this knowledge comes from the rock samples that the astronauts brought back with them from the moon. These samples were one of the greatest benefits of sending humans to the lunar surface. Before their missions, the astronauts went through training, to recognize different types of rocks and their significance.

NASA's Vision for Space Exploration calls for a return to the moon before going to Mars, and beyond. We'll learn how to "live off the land" by making oxygen and rocket propellants from the local materials, and we'll be testing new technologies and operations. Living and working on the moon will be a test run for living and working on Mars and beyond.

In this lesson, you will locate and simulate the mining of ilmentite for it's oxygen from the surface of the moon. You will then collect the oxygen that is extracted from the ilmenite.

- If needed, additional research can be done on the following science topics:
    - Apollo mission with lunar sample returns (11, 12, 14, 15, 16, 17)
    - ilmenite
    - geology / geologist
    - metamorphic rock
    - igneous rock and the formation of glass
    - spectroscopy
    - solar energy

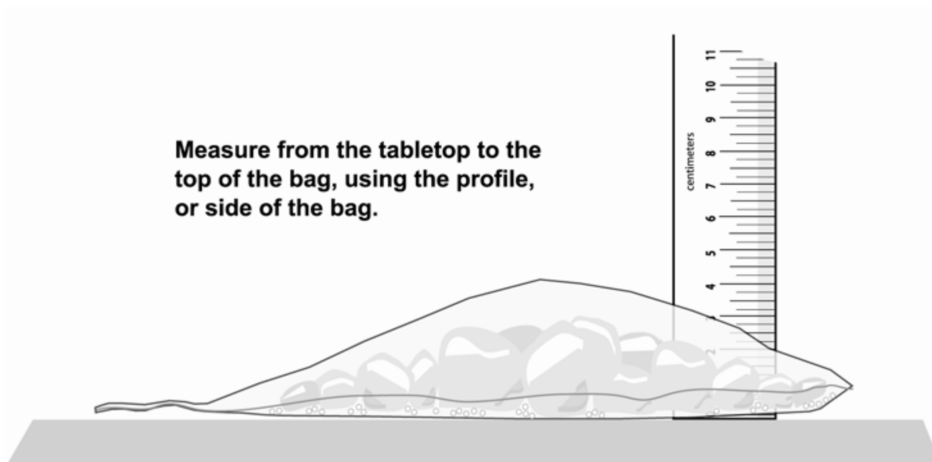
Instructional Procedure

Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section.

1. Show NASA's KSNN™ 21st Century Explorer newsbreak "Why return to the moon before going to Mars?" to engage students and increase student knowledge about this topic.
2. Review the problem with the students.
   Problem: How can I find and mine valuable resources from a simulated moon surface?
3. Have the students read the ***Observation*** Section in the Moon Mining Student Section and discuss in their groups.
4. Encourage your students to discuss and make ***observations*** about this topic by completing the first two columns in the KWL (KNOW/WANT TO KNOW/LEARNED) chart on the Moon Mining Student Section. Use the KWL chart to help students organize prior knowledge, identify interests, and make real-world connections. As students suggest information for the "KNOW" column, ask them to share "How they have come to know this information."
5. Ask your students if they have predictions relating to this activity and the "problem question". Help them refine their predictions into a ***hypothesis***. In their Student Section, they should restate the "problem question" as a statement based upon their observations and predictions. Encourage students to share their hypothesis with their group.
6. Students will ***test*** their hypothesis following this procedure.
   (The following steps are taken from the Student Section. Educator specific comments are in italics.)
    1. Put on your safety glasses.

       Stress the importance of keeping eye protection on during this portion of the lesson.
    2. ***Observe*** your disposable plate moon with your partner.
    3. Draw a line to divide the graph paper in half. Sketch your disposable plate moon on one half of the graph paper. Label your drawing. Title the drawing "Before Mining".
    4. Place red transparency on half of the plate, and blue transparency on the other half.
    5. Look for ilmenite (effervescent tablets) by moving the transparencies around the plate. What color can you see the ilmenite through? What color hid the ilmenite? NASA researchers use colors to locate certain items on the surface of other bodies. This is called "spectroscopically" locating the ilmenite.

6. When the ilmenite is located, extract the section it is in from the disposable plate (take it off of the plate with the spoon) and place it into the zipper seal bag. Zip the bag, making sure all air is locked outside the bag.
7. Place the bag in a sunny location. This represents the solar energy that may be used to power the machinery that extracts the oxygen from the ilmenite.
8. Evenly flatten out the contents of the bag by pushing it down with your palms. This will allow you to see the profile, or side, of the bag.
9. ***Observe*** the bag. Sketch an outline of what the profile of the bag looks like on your Moon Mining Data Sheet.
10. Measure from the tabletop to the top of the bag, using the profile, or side, of the bag. ***Record data*** on your Moon Mining Data Sheet at zero minutes. (See diagram.)



11. Predict how the bag will change over time, and record your prediction on your Moon Mining Data Sheet.

    You may want to guide the class into what they think might happen to the bag to make their predictions.

12. Guess what is inside the bag. ***Record*** on your Moon Mining Data Sheet.
13. Every 3 minutes for the next 12 minutes, repeat steps 9-12. Do not disturb the ilmenite sample.

    Not disturbing the bag is important to the experiment. Have students measure and observe without touching or moving the bag.

14. Discuss what you see happening to your zipper sealed bag with your group. Why is the ice melting?
15. Sketch your disposable plate moon on the other half of the graph paper. Make sure you label where the ilmenite was found. Label your drawing. Title your drawing “After Mining”. What are these deep places on the moon called?

    Have your students compare the “mined” ilmenite drawing with the original moon drawing. Ask students to discuss the differences they see.

16. After taking all measurements, ***study the data*** and ***draw conclusions*** by answering the questions following the Moon Mining Data Sheet.

    Sample answers to the Study Data questions on the Moon Mining Student Section:

    1. giving off gas (simulated oxygen)

2. energy, can be solar energy

3. all over the moon, the darker areas of the moon's surface, mostly craters

4. using colors, or possibly using other methods such as magnets

Using this information, ask students to determine if the data supports or refutes their hypothesis.

Conclusion

- Discuss the answers to the Moon Mining Student Section questions.
- Have the students update the LEARNED column in their KWL chart.
- Ask students to compare their individual data to the class data. What patterns can be found?
- Is there another way that you could find this ilmenite? Brainstorm how.
- Ask students "what they wonder now?" Encourage students to design their own experiments. What other objects could have been used for the land surface?
- What other items necessary for human life can be taken from the surface of the moon?

Assessment

- Assess student knowledge through questioning.
- Observe and assess student performance throughout the activity using the attached Scientific Investigation Rubric.

Activity Alignment to National Education Standards

National Science Education Standards (NSES):
Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry (K-8)
- Understandings about scientific inquiry (K-8)

Content Standard D: Earth and Space Science

- Properties of Earth materials (K-4)
- Structure of the Earth system (5-8)

Content Standard F: Science in Personal and Social Perspectives

- Science and technology in local challenges (K-8)

National Mathematics Education Standards (NCTM):
Data Analysis and Probability Standard:

- Develop predictions that are based on data

U.S. National Geography Standards (NCGE):

- Standard 14: How human actions modify the physical environment
- Standard 16: The changes that occur in the meaning, use, distribution, and importance of resources

Curriculum Explorations

To extend the concepts in this activity, the following explorations can be conducted:

Mathematics

Ask students to display their data in any way that they choose. Ask them to explain why they have chosen to display their data in this format.

Analyze the data, looking for patterns and trends.

National Mathematics Education Standards (NCTM):

Algebra Standard:

- Understand patterns, relations, and functions
  - represent and analyze patterns and functions, using words, tables, and graphs

Data Analysis and Probability Standard:

- Develop and evaluate inferences and predictions that are based on data
  - propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions

Language Arts

Ask students to explain the experiment. How might students improve this experiment? Where might there have been mistakes made? How might these mistakes have affected the results?

National Council of Teachers of English Standards (NCTE):

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

History

Research the ownership of the moon. Are there laws that protect space travelers and property in space?

National Council for Geographic Education (NCGE):

Standard 18: To apply geography to interpret the present and plan for the future.

Sources and Career Links

Thanks to subject matter experts Michael Wargo, Kay Tobola, Christine Shupla, Dr. Donald Bogard, Dr. Gary Lofgren, and Harrison Schmitt for their contributions to KSNN™ and Noticiencias NASA™ on the development of this education material.

Michael Wargo is an Exploration Systems lunar scientist. You can find out more about what Mike does at: http://www.nasa.gov/vision/earth/everydaylife/real_glass.html.

Kay Tobola is an educator with ARES (Astromaterials, Research and Exploration Science) at NASA Johnson Space Center. Learn more about ARES at http://ares.jsc.nasa.gov/.

Christine Shupla is an educator with The Lunar and Planetary Institute (http://www.lpi.usra.edu/).

Dr. Donald Bogard, chief scientist, astromaterials, NASA Johnson Space Center was instrumental in the formation of the background information for this activity. You can find out more about what he does here http://ares.jsc.nasa.gov/People/bogarddon.html.

Dr. Gary Lofgren is a planetary geoscientist/ lunar curator, director of the experimental petrology laboratory at NASA JSC. Dr. Lofgren was instrumental in the educational formation of these activities. You can find out more about Dr. Lofgren at this site http://ares.jsc.nasa.gov/People/lofgrengary.html.

For a related career profile, learn about Apollo 17 Lunar Module pilot Harrison Schmitt, who was a professional geologist before becoming an astronaut. Find out more by visiting http://www.hq.nasa.gov/office/pao/History/alsj/a17/a17.crew.html.

Lesson development by the NASA Johnson Space Center Human Health and Performance Education Outreach team.