Electromagnetic Spectrum: Remote Sensing Ices on Mars

Presented by: Rudo Kashiri

October 4, 2012
7:30 p.m. – 9:00 p.m. Eastern time
Introducing today’s presenter...

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Electromagnetic Spectrum - Remote Sensing Ices on Mars

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NASA + YOU = FUTURE
Presentation Outline

- Buried Water Ice on Mars Overview
- NASA Connection
  - Mars Odyssey Spacecraft
- Featured Lessons
  - Remote Sensing Ices on Mars
  - Remote Sensing with Gamma Rays
- NASA Explorer Schools
Buried Water Ice on Mars

Middle and High school
Physical and Earth science
National Science Standards
- Structure and properties of matter
- Interaction of energy and matter
Use real data from Mars
What does the map tell us about Mars?
Buried Water Ice on Mars

LESSONS:

- Why Follow the Water
- Remote Sensing Ices on Mars
- Dirty Ice or Icy Dirt
- Mars Exploration Debate
- Dirty Ice Snowcones
- Mars Image Analysis Extension Activity
Let’s Pause for Questions.
Follow the Water

When • Where • Form • Amount

Life
Climate
Geology
Prepare for Human Exploration

NASA Mars Science Strategy
Remote Sensing

Mars Odyssey Orbiter

Mars Reconnaissance Orbiter
Disappearing Ice
Thermal and Evolved-Gas Analyzer (TEGA)
Mars Rover Family
Let’s Pause for Questions.
2001 Mars Odyssey Spacecraft

- Thermal Emission Imaging System (THEMIS)
- Gamma Ray Spectrometer (GRS)
- Mars Radiation Environment Experiment (MARIE)
Gamma-Ray Spectrometer
Neutron and Gamma Ray Production
EMISSION (BRIGHT LINE) SPECTRA

- Helium
- Strontium
- Barium
- Calcium
- Hydrogen
- Sodium

ABSORPTION SPECTRUM
GASES IN SUN'S ATMOSPHERE (PRINCIPAL FRAUNHOFER LINES)
Let’s Pause for Questions.
Lesson in Detail

Materials
- Computer with projector, or overhead with transparency
- Computers (extension)

Optional
- 1 clear pitcher
- Liquid water and water ice
- 1 thermometer
Type of Data

- Visible albedo
- Surface temperature
- Elemental composition
Why is solid water more likely to be found on the surface of Mars than liquid water?

A. Temperature is too cold
B. Air pressure is too low
C. Both A and B
Background Information

Ice properties

- Phase change
- Molecular structure
- Frost point temperature
- Sublimation
What do you think the white areas are?
Let’s Pause for Questions.
Types of Light

[Diagram showing the electromagnetic spectrum with different types of light and their wavelengths and energies.]
Visible Light Images

Northern Winter

Northern Summer
What is the surface temperature of the ice cap during the winter?
Gamma Ray Data

North Pole Winter - GRS Hydrogen Signal

North Pole Summer - GRS Hydrogen Signal

Relative Hydrogen Signal Strength
Background Reading

Life as we know it requires water. A key NASA science goal is to study past and current water on Mars. Liquid water is unstable under current Mars conditions. This is because temperatures are too cold, and the air pressure is too low. However, solid water, known as ice, and other types of ice can be stable. Studying these types of ice helps us understand what Mars is like today and may have been like in the past.

Ice Properties

In this activity, we will look at the types of ice found at high latitudes on Mars. We will also study how the ice caps on Mars change during different seasons. We will evaluate four different substances that could form ice: water, carbon dioxide, ammonia, and methane. The table below summarizes properties for each of these if solid ice near the surface of Mars.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Density (g/cm³)</th>
<th>Melting Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.997</td>
<td>0</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>0.831</td>
<td>-78</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.948</td>
<td>-127</td>
</tr>
<tr>
<td>Methane</td>
<td>0.815</td>
<td>-89</td>
</tr>
</tbody>
</table>

Part 1: Visual Data

The images in this activity were collected by spacecraft orbiting Mars. We will look at Mars’ north polar icecap. Notice the presence of light and gamma rays. Vision data will help us locate key ice units to study their properties.

1) Draw a circle around the location of the Polar Ice Cap during each of the seasons above. How can you tell the difference between polar ice and surrounding rock and soil?

2) Is the ice cap larger during the winter or during the summer? Give a possible explanation for your answer.

3) Can you determine whether the winter or summer ice caps are larger? Explain your answer.
Visible Light Data
Does Mars Have Seasons?

- Solstice: Southern Summer, Northern Winter
- Equinox: Southern Fall, Northern Spring
- Equinox: Southern Spring, Northern Fall
- Solstice: Southern Winter, Northern Summer
Let’s Pause for Questions.
EXTENSION ACTIVITY

Remote Sensing Ices on Mars
Types of Light

- Radio
- Microwave
- Infrared
- Visible
- Ultraviolet
- X-ray
- Gamma Ray

Energy:
- Low Energy
- High Energy

Wavelength (meters):
- Radio: $10^3$
- Microwave: $10^{-2}$
- Infrared: $10^{-5}$
- Visible: $0.5 \times 10^{-6}$
- Ultraviolet: $10^{-8}$
- X-ray: $10^{-10}$
- Gamma Ray: $10^{-12}$

About the size of:
- Buildings
- Humans
- Honey Bee
- Pinpoint
- Protozoans
- Molecules
- Atom
- Atomic Nuclei
Neutron and Gamma Ray Production
The Mars Gamma Ray Spectrometer (GRS) instrument suite aboard the Mars 2001 Odyssey spacecraft collects gamma ray photons and neutrons released from Mars. These particles allow us to measure the composition of the surface of the planet. The DEMO module will help you visualize the nuclear processes that cause gamma ray photons and neutrons to be released from the planet. The SIMULATOR module will help demonstrate how we can identify different surface compositions on Mars depending upon the type of gamma ray photons and neutrons released from the planet. The EVALUATION module provides an opportunity for you to test your understanding of how gamma ray photons and neutrons are released from Mars and how these particles are useful in mapping the surface of Mars.
Spallation Event:

Cosmic ray particle smashes into Mars.

This animation shows a cosmic ray particle, in this case a fast moving hydrogen proton, smashing into the surface of Mars. Neutrons are knocked off of the atom that the cosmic ray particle hits in a process known as spallation.
When you press PLAY, this simulation shows neutrons (yellow spheres) and gamma ray photons (arrows) leaving the surface of Mars as a result of radioactive decay and bombardment by cosmic ray particles (red spheres). To learn more about these processes, go to the DEMO by clicking on the button at the upper right. Unlike the DEMO, in this simulation we do not show individual atoms or molecules at the surface of Mars. Note also that the simulation is not drawn to scale.

As the Mars 2001 Odyssey spacecraft orbits the planet, it detects some of the neutrons and gamma ray photons from Mars with its Gamma Ray Spectrometer (GRS) instrument suite. The count table or graph to the left shows the number of neutrons ($n$) and gamma ray photons from hydrogen ($H$), silicon ($Si$), chlorine ($Cl$), iron ($Fe$), and potassium ($K$) that GRS has detected over the course of the simulation.

You can select different soil compositions by clicking on the three buttons at the upper left. Each of these simulates a different soil composition and gives off a different number of neutrons and gamma ray photons. For each composition of soil, run the simulator to build up enough detections by GRS to determine the composition of the soil. You should be able to see composition differences after about 10 GRS passes (shown at the bottom left).

How do the three compositions of the soils compare? Which is rich in Nitrogen? Which is rich in radioactive Potassium?
Can Mars GRS collect all of the particles given off by Mars?
Why is it important for Mars Odyssey to collect data over a long period of time?

Show Count
GRS Passes:
1. Cosmic ray particles from outer space smash into Mars, which gives off neutrons and gamma rays photons of energies specific to the elements in the soil.
2. Potassium gives off gamma photons are given off by radioactive decay.
3. Mars 2001 Odyssey detects some of these neutrons and gamma rays to determine the composition of the top meter of the planet surface.

Depth:
0 meter(s)
How does the composition of soils compare?
Evaluation

Test your understanding of how gamma ray photons and neutrons are released from Mars and how these particles are useful for determining the composition of the planet. Press START to begin answering the nine questions provided. You can exit out of this module to the DEMO or SIMULATOR modules by clicking on the boxes to the upper right at any time. You can then return to the EVALUATION module to continue answering the questions. Good Luck!!!

For additional information, go to the following website: http://grs.lpl.arizona.edu.
Question 2
Which of the following typically gives off free neutrons at the surface of Mars?

a. Cosmic ray particle smashing into Mars
b. A volcano erupting explosively
c. Sublimation of the polar ice caps during the summer months
d. Ultraviolet photons hitting the surface of the planet
Question 2

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Previous Question

Reset

Next Question
Correct! Cosmic ray particles release free neutrons through a process called spallation. Watch and read the DEMO titled "Radioactive Decay Event."
Remote Sensing Ices on Mars Extension
Teacher Guide
Remote Sensing With Gamma Rays

Background Reader
The Mars Gamma Ray Spectrometer (GRS) aboard the 2001 Mars Odyssey spacecraft has been designed to map the composition of the near-surface of Mars using Gamma rays. Even though the spacecraft is not in direct contact with the surface, we can use these to learn about the surface of the planet. First, access the Mars Gamma Ray Simulater by going to the following website:

http://grs.jpl.nasa.gov/remote/human/teacher/simulator

This will take you to an introduction page with a brief introduction. Click the Mars RLS button to proceed. Read the brief introduction.

Next, click on the number 10 GRS passes (see counter towards lower right of the screen) and complete the following table with the number of neutrons and gamma photons collected. Notice that you can click on the Show Error button to list the actual number of photons collected.

<table>
<thead>
<tr>
<th>Soil Composition 1</th>
<th>Soil Composition 2</th>
<th>Soil Composition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10)</td>
<td>(10)</td>
<td>(10)</td>
</tr>
<tr>
<td>-10</td>
<td>-10</td>
<td>-10</td>
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<td>-90</td>
</tr>
<tr>
<td>-100</td>
<td>-100</td>
<td>-100</td>
</tr>
</tbody>
</table>

Next, click on the Simulator button found towards the upper right of the screen. Read the description of the simulator found there. Select one of the Soil Compositions found towards the left side of the screen and click on the Play button found towards the bottom of the screen. This simulator shows ceramic ray particles (red spheres) bouncing off the surface of Mars which cause the release of neutrons (yellow spheres). Some of these neutrons escape to space or others cause the release of gamma ray photons (colored arrows) through either scattering or capture events. In addition, radioactive elements give off gamma ray photons through decay events. For each soil composition, run the simulation for 10 GRS passes (see counter towards lower right of the screen) and complete the following table with the number of neutrons and gamma photons collected. Notice that you can click on the Show Error button to list the actual number of photons collected.

Next, click on the XRD button to exit the simulator.

1) Describe each of the three ways that gamma rays are used to learn about the surface of Mars.

Neutron scattering:

Sometimes a neutron bounces off an atom and energy is released in the form of a gamma ray photon.

Neutron capture:

Sometimes a neutron is captured by an atom, which makes the atom temporarily radioactive. When the atom decays to a more stable state, it gives off a gamma ray photon.

Radioactive decay:

Radioactive elements such as potassium, thorium, and uranium are unstable. When one of these atoms decays to a more stable state, it gives off a gamma ray photon.

Remote Sensing Ices on Mars Extension
Remote Sensing With Gamma Rays
Let’s Pause for Questions.
Why NES?
NASA Now classroom videos

✓ Words to know
✓ Discussion questions
✓ Career information
✓ Corresponding teaching materials
✓ Log your participation
Live video chat
Featured Lesson(s)
Remote Sensing Ices on Mars

Essential Question
How is remote sensing used to draw conclusions about the physical and chemical nature of planets?

Description:
The Mars Odyssey spacecraft discovered significant amounts of water ice buried in the high-latitude regions of Mars. The discovery was based on analysis of data from the Mars Gamma Ray Spectrometer. This classroom activity in this module is related to this discovery. The activity guides students to understand that seasonal carbon dioxide ice covers buried water ice during the winter season and that the permanent ice caps in the northern and southern hemispheres are made of different types of ice. In the extension activity, students use a computer simulation illustrating how remote sensing is used to determine the composition of the Martian surface.

Additional Resources

- Classroom Resources:

- Related NASA Now Events:

- Connection to NASA:

- Extension Activities:

Professional Development:

- Click here to find the live web seminars scheduled for this featured lesson. Web seminars are led remotely by NASA subject matter experts and education specialists.

- Click here to access the teacher video on featured lesson.

- Professional Development:

- Survey
  
  - I used this featured lesson in my classroom.
  
  - I watched the teacher video collection associated with this featured lesson.
  
  - I attended the live web seminar associated with this featured lesson.

- National Content Standards:

- Materials Needed:

- NES Video Collections:

  - Electromagnetic Spectrum
  
  - Grade Level: 8-10
  
  - Activity Type: Student investigation
  
  - Time to Complete the Activity: Two class periods (100 minutes)

Log Your Participation to become eligible for NES Recognition
Completed surveys will be added to your My Activities page
Take the Survey Now

Video Collection
Thank you for joining us today!

Rudo Kashiri

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http://explorerschools.nasa.gov
Thanks to today’s presenter!

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