Mission 11 ALT Logbook
Mission to Mars – Spectroscopy
Can You detect signs of past water?
Elemental Fingerprints Worksheet 1

Name: Date:

Known Emission Spectra
Draw the spectrums of the following elements (or sources of light) as you see them in class today.

1. Fluorescent light or incandescent light bulb

2. Sunlight

3. Helium

4. Hydrogen

5. Oxygen

6. Neon

7. ______________________

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Elemental Fingerprints Worksheet 2

Name: Date:

Mystery Spectra
Identify the elements in spectra A, B, and C by comparing the bright lines present with the bright lines in the spectra for known elements.

Helium
Hydrogen
Sodium
Lithium

Spectra A Elements: ______________________________

Spectra B Elements: ______________________________

Spectra C Elements: ______________________________

If spectrum A, B, and C were samples of spectroscopy data collected by the Mars Global Surveyor, what could you say about the chemical composition of the surface of Mars?

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Identifying Mystery Spectra Directions

1. Obtain copy of the Known Spectra Transparency and the Mystery Spectra card.

2. Overlay Known Spectra Transparency on top of Mystery Spectra so that only have of the Mystery Spectra is covered.

3. If pattern of brightness lines matches up for a given spectra, the element is present in the Mystery Spectra.

4. Repeat this process for each element in each Mystery Spectra given.

5. Your teacher will model the identification process for the one element found in Spectra A.

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Mission 11ALT
Mission to Mars Spectroscopy!
Can You Detect Signs of Past Water?

Overview

In mission 11.1, students will explore a few of the basic properties of light as a wave. They will study the dispersive properties of light, and examine how light can be broken up into its elemental components known as a spectrum. Students will learn how scientists use spectrographs to determine not only what stars and galaxies are made of, but the elemental composition of a planet's surface. In mission 11.2, students will compare the spectra of a known set of sources in order to identify elements present in a mystery spectrum. Students will learn how Mars scientists are using spectroscopy to look for evidence of past water on its surface.

Notes:

In Mission 4, students tested for life in the solid of an alien planet. If an extraterrestrial scientist sent a robotic spaceship to earth to search for life, where exactly would they land the robotic spaceship? How do they determine their landing site?

Mission 11.1
Materials

For a Class of 30

- Spectroscopes
- Set of colored pencils

For Each Student
- "Spectroscopy" worksheet
- pencil

Getting Ready

1. If you do not have spectroscopes available, you can prepare diffraction gratings ahead of time or have students make their own that they can take home. Follow the instructions in the appendix (see "Making Your Own Diffraction Gratings").

2. This activity works best in a darkened room. Be sure all blinds/curtains are drawn. An economical window covering for classrooms with a lot of windows are pond liners found in most home improvement warehouse stores.

3. Gather emission tubes containing gases including neon, helium, oxygen, and hydrogen, along with holders for the tubes and power supply for emission tubes. If you have other gas emission tubes include those in the activity as well.

If you have enough power supplies, a less teacher centered approach to this activity is to set up spectra stations. Students rotate between stations to view the emission spectra of each type of gas.

4. Copy the "Spectroscopy!" worksheet for each student.

5. Practice with a glass prism and an overhead projector creating a rainbow on one of the classroom walls. If a glass prism is not available, a holographic grating works just as well.

Classroom Action

1. **Discussion.** Ask how many students have seen a rainbow some time in their life? Ask them to think about how a rainbow is made. Have students share with a partner their thoughts? Limit discussions to 15-20 seconds for each partner. Ask for volunteers to share their ideas with the entire class. Students will typically mention that it is related to the raindrops and sunlight. Ask them to describe what the raindrops do to the sunlight. The raindrops break up the white light into all the colors that make up white light. This is a process called dispersion and it works because different colors of light travel at different speeds through different types of materials (media). Share with students examples of other types of materials that break up white light into its component colors (oil, bubbles, prisms, etc.) Using the overhead projector and prism, project a rainbow on a classroom wall/ceiling so that it is visible to all. Stress that white light is simply all the colors of the rainbow added together. The physical properties of a prism enable us to break up white light into its component colors. You may want to point out that the blue light is on the bottom because it travels slower through the prism, which is Explain that these colors are all part of the electromagnetic spectrum. Electromagnetic spectrum is a general term used to describe all light (all wavelengths of electromagnetic radiation). The colors of the rainbow that we see are part of the range of light known as the visible spectrum. It is called the visible spectrum because it is the range of the electromagnetic spectrum that our eyes are sensitive to, it is the light we can see.

2. Explain that they are going to look at the component colors of several different sources of light. Distribute the diffraction gratings to the students. Instruct students how to handle the gratings, noting that oils from their fingers can clog the grooves and prevent them from working well. Tell students to handle them on the edges only. Tell students that diffraction gratings act like prisms and separates light into its component colors.

   If students have trouble seeing the spectral lines with the diffraction grating, suggest that they rotate the grating a quarter turn (90°), because the lines in the grating may be lined up the wrong way. Also, suggest that they look way off to the side when looking through the grating, not straight at the light. They may also need to move closer to the light source.

   If students are using spectroscopes, instruct them to aim the spectroscope so that light from the gas emission tube enters through the small slit.

3. Distribute the "Spectroscopy" worksheet and colored pencils. Inform students that they will be drawing in the spectra of a variety of light sources. Begin with the spectra of an incandescent light bulb or florescent classroom lights will be sufficient. Model for students how they should draw the spectra on their "Spectroscopy" worksheet. Then have students step outside and draw in the spectra of sunlight. SAFETY TIP: Regardless of which type of dispersion device students are using, instruct them to look at indirect sunlight. Do not aim spectroscope slit or point diffraction grating directly at sunlight. When students return to classroom, project on screen or draw on the board what their sunlight spectra should look like. It should be a continuous spectrum, a rainbow.

4. Be sure room is as dark as possible. If spectra stations are not set up, display gas emission tubes one by one allowing enough time for all students to draw in their emission spectra. Encourage students to carefully move closer to toward the gas emission tube to get the best view. Reminding them to be careful as they navigate through the classroom in the dark.

   If spectra stations are set up, give safety instructions before you darken the room. Have students move in small groups between the stations. Inform them that you instruct them to rotate once everyone has had an opportunity to view the spectra. Students should bring their worksheets and colored pencils with them to each station. If there is not a lot of table space at each station, ask students to also take with them something sturdy to write on.

5. Once all students have had the opportunity to view each spectra and have returned to their seats, ask them to review the spectra they drew and make some comments about what they notice or observe from their spectra. In a round table discussion, students share their thoughts with teammates. Allow about 1-2 minutes for the round table discussion. Elicit volunteers to share their table discussions.

   Students should have noticed that with the individual gas emission tubes, no two spectra were the same. Explain to students that just like each human being has a unique set of fingerprints, each element has a unique spectrum. It is this property of elements that is used to identify what stars, galaxies, and planets are made up of.

Mission 11.2
Materials

For Each Team

- Known spectra transparency
- Mystery Spectra Card
- Identifying Mystery Spectra directions

For Each Student

- "Elemental Fingerprints Worksheet 2" worksheet
- Pencil

Getting Ready

1. Print "Known Emission Spectra" on an overhead transparency. Print the "Mystery Spectra" on cardstock or put in a plastic sheet protector so you can reuse. Print one set of "Mystery Spectra" on a transparency for demonstrating identification process.

2. Prepare one for each student "Elemental Fingerprints Worksheet"

3. Set up overhead projector.

Classroom Action

1. **Activity.** Reassemble the class into mission 11.1's teams.
2. Hand out the "Elemental Fingerprints" Worksheet and "Identifying Mystery Spectra" directions. Have students review work they completed yesterday with a partner. Students should recall that they studied the spectra of a variety of different elements. They should also state that each spectra is unique for a given element. Point out to students the position and separation of bright lines in an emission spectra are also unique for a given element.
3. On overhead projector model for students how they are to use known spectra sets to identify elements present in mystery spectra. Overlay known spectra over mystery spectra to check for sets of lines that match exactly. Please note all lines present in known spectra must be found in mystery spectra to indicate the presence of that element in the mystery spectra. With students walk through identifying one of the elements present in Mystery Spectra A. See Elemental Fingerprints key for answers. Allow student teams to finish identifying mystery spectra on their own.
4. Once all teams have completed the worksheet. Show "Water on Mars?" slide show. See "Water on Mars?" script for slide show narration.

Water on Mars? slide show script.
Slide 1.

Spectroscopy is a tool employed by many scientists. Astronomers typically use spectroscopy to determine the chemical composition of a star or a nebula.

Slide 2. More recently planetary geologists have been using spectroscopy to find evidence of past water on a planet's surface, in particular Mars. There are several missions on Mars whose objective is to find evidence of water past or present on Mars.

Slide 3. One such mission is the Compact Reconnaissance Imaging Spectrometer for Mars, CRISM, which is on board the Mars Reconnaissance Orbiter, MRO. The Mars Reconnaissance Orbiter (MRO) is a satellite loaded with instruments whose primary mission is to determine the history of water on Mars. MRO instruments will zoom in on the planet's surface to analyze features and determine the chemical composition of the surface.

Slide 4. CRISM uses spectroscopy to analyze the component energies of light reflected off the surface. From these reflected spectra, scientists can identify minerals that formed in liquid water.

Slide 5. Scientists use a similar technique used today to identify these water formed minerals, except instead of studying bright line spectra, they look at spectral curves created by specific types of surfaces when light is reflected off of the surface. These curves are created by converting the wavelengths of light seen in a bright line spectra into corresponding energy values. Spectral curves from light reflected off vegetation look completely different from spectral curves from light reflected off of water or plain soil.

Slide 6. The spectroscopy work CRISM scientists do create images such as these which is an image of phyllosilicates and olivine in the Nili Fossae region of Mars. The presence of silicates indicates the presence of water in the past.

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Elemental Fingerprints Worksheet KEY

Known Emission Spectra
Draw the spectrums of the following elements (or sources of light) as you see them in class today.

1. Fluorescent light or incandescent light bulb

2. Sunlight

Student sketches should approximate the Sun's spectrum:

3. Helium

Helium

4. Hydrogen

Hydrogen

5. Oxygen

6. Neon

7. ____________________

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Elemental Fingerprints Worksheet KEY

Mystery Spectra
Identify the elements in spectra A, B, and C by comparing the bright lines present with the bright lines in the spectra for known elements.

Helium


Hydrogen


Sodium


Lithium

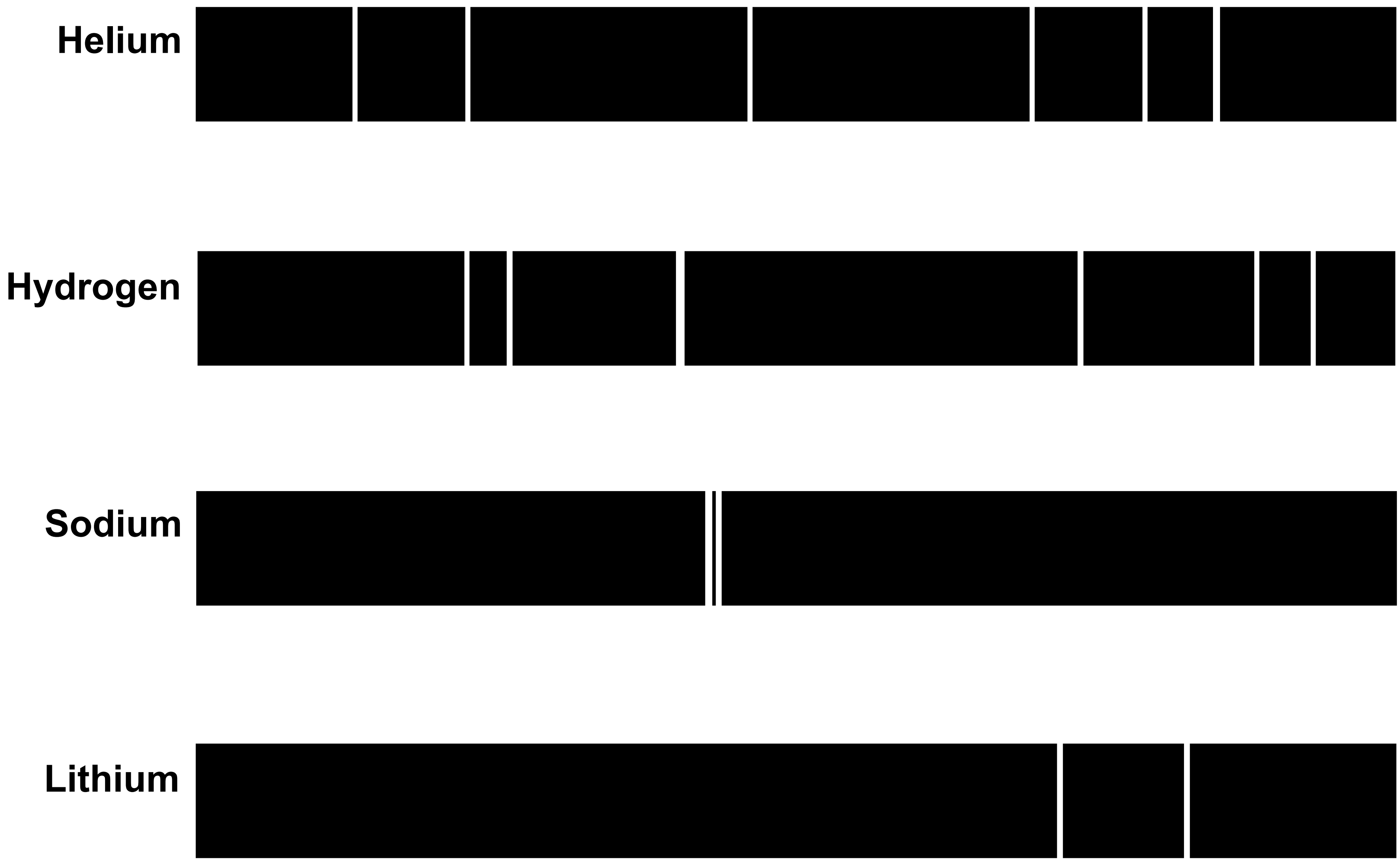

Spectra A Elements: Sodium & Lithium


Spectra B Elements: Hydrogen, Lithium


Spectra C Elements: Helium, Hydrogen, Lithium


If spectrum A, B, and C were samples of spectroscopy data collected by the Mars Global Surveyor, what could you say about the chemical composition of the surface of Mars?
It contains sodium, hydrogen, lithium, & helium.

Known Spectra

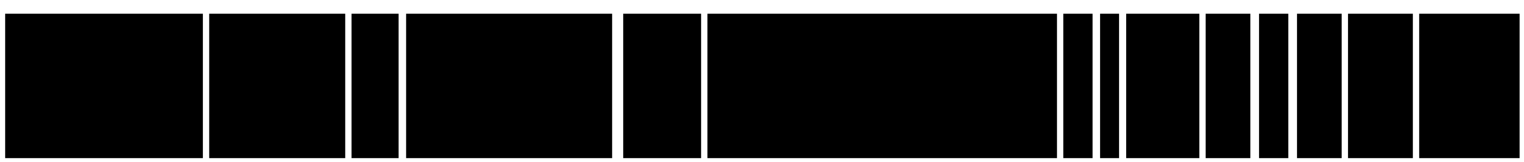


Mystery Spectra

Spectra A Elements: ______________________________

Spectra B Elements: ______________________________

Spectra C Elements: ______________________________



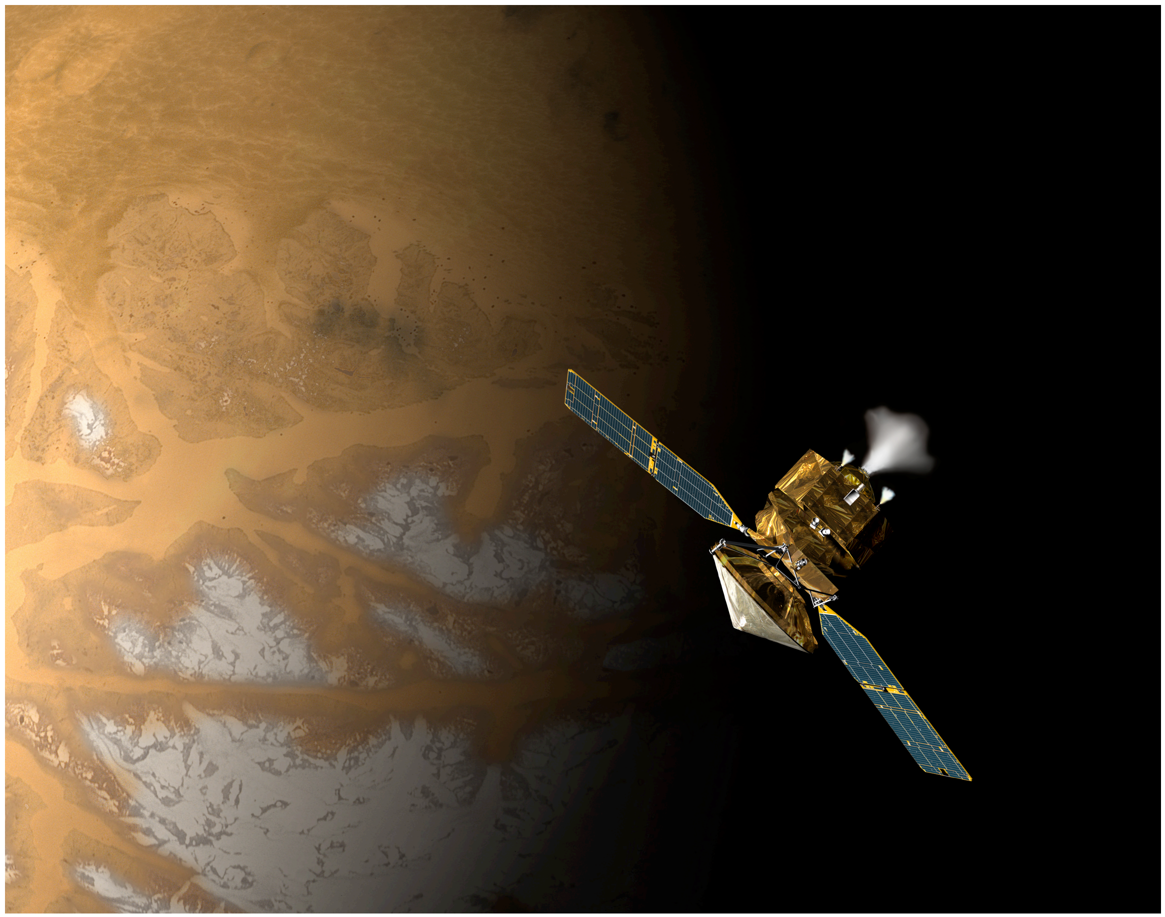
Water on Mars?

Credit: Marita Beard

Mars

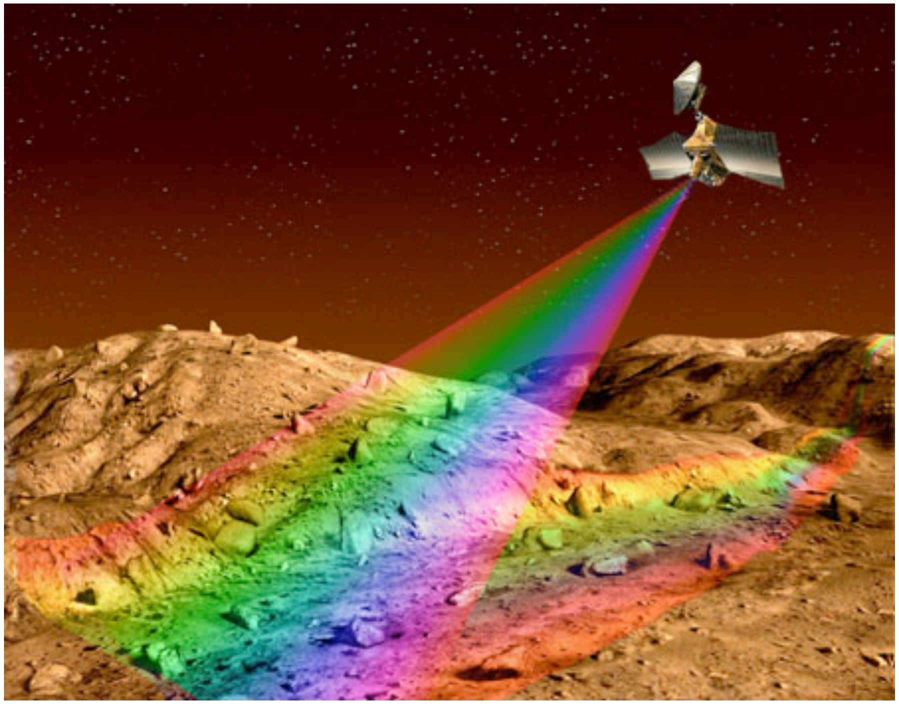
Credit: NASA

Mars Reconnaissance Orbiter



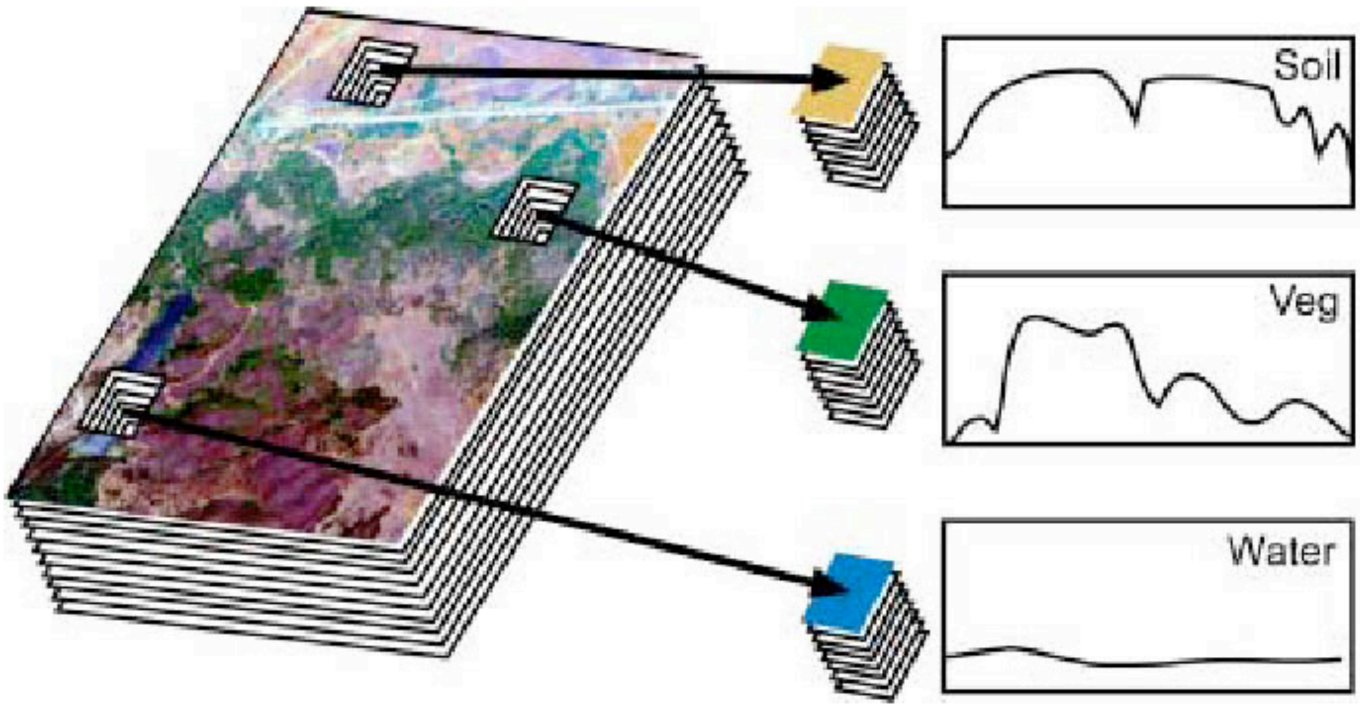
Credit: NASA

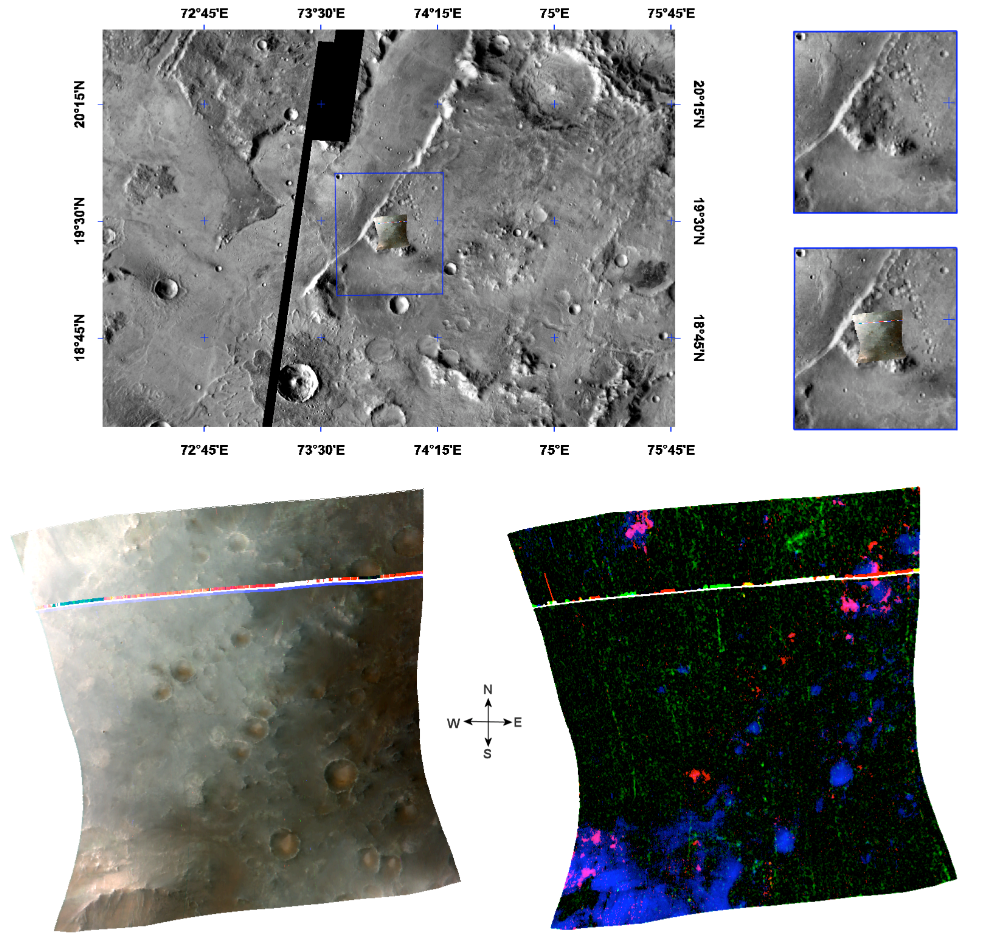
Compact Reconnaissance Imaging Spectrometer for Mars



Credit: NASA

Reflectance Spectroscopy





infrared false color

red/pink = iron/magnesium phyllosilicates

green = aluminum phyllosilicates

blue = olivine

Credit: NASA