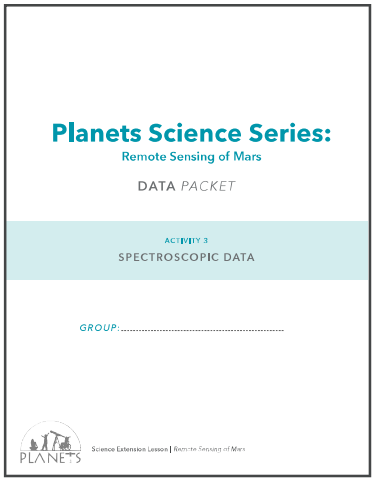
Activity 3: Mineral Fingerprinting (40 min)

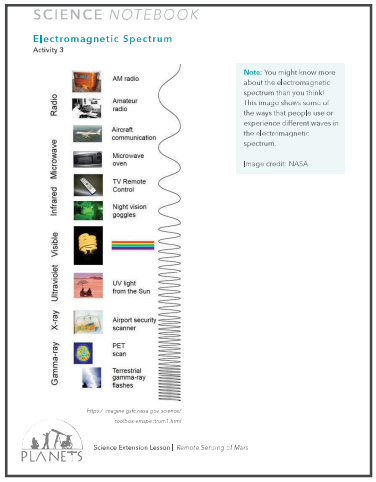
Overview

How can we use minerals to help us identify where water may have been on Mars? In this activity, youth learn that spectroscopy lets us see the "fingerprints" of different minerals. They examine images of regions on Mars and use spectral data to decide which location has the most evidence for past water on Mars, based on the minerals they discover.

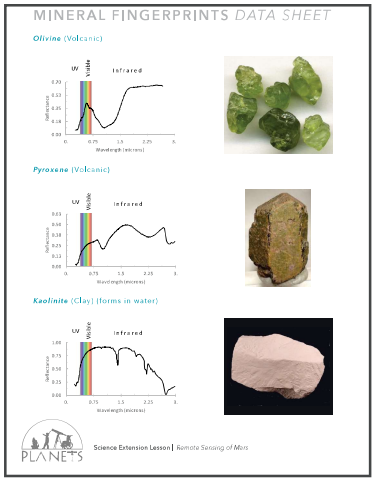
In this activity:



Spectroscopic Data Packet
1 per group



Science Notebook
1 per youth



Mineral Fingerprints Data Sheets
1 per group

Introduction to Spectrometry (10 min)

1. Ask youth to look at the electromagnetic spectrum figure on pg. 6 in their Science Notebooks and let them know that this diagram shows all the wavelengths of light, even the ones that our eyes can't see. Tell youth that remote sensing instruments called spectrometers can help us see many other types of light that our eyes cannot detect.

   Note: For more on what the rainbow would look like to other animals, listen to this episode of Radiolab: https://www.wnycstudios.org/podcasts/radiolab/segments/211178-rip-rainbow

   » Some other animals can see types of light that humans can't. For example, butterflies can see ultraviolet light, certain snakes can detect infrared light, and an animal called the mantis shrimp may be able to see an enormous range of colors beyond what we can.

2. Let youth know that spectrometers measure light in different wavelengths/colors, including those that the human eye can't see. The measured spectral data are graphed to show how much light of each wavelength was measured. This graph is called a spectrum. The shape of the spectrum can tell us what rocks and minerals are on the surface of Mars.

   Tip: "Spectrum" is singular and "spectra" is the plural form of the same word.

3. Explain that all materials (including minerals) either absorb or reflect different colors of light, so each unique spectrum is like a "fingerprint" that can be used to identify the material.

   » The concept of spectra builds upon the color filters used in the Engineering Everywhere Worlds Apart: Engineering Remote Sensing Devices activities, available at planets-stem.org/remote-sensing. If you measured the brightness of something using a lot of different filters, each tuned to a specific wavelength of light, you would end up with a spectrum. In other words, using a filter lets us see the light from one specific piece of the full spectrum.

Observing Different Spectra (15 min)

1. Have youth refer to the figure on p. 7 in their Science Notebooks showing the spectra of summer and fall leaves. Guide them to understand what the red and green lines mean: they show how much light is reflected from the leaf at each wavelength. Point out the rainbow representing the part of the electromagnetic spectrum that is visible to humans.

   » Ask youth to make observations of the two spectra. The spectrum of the green leaf shows the highest reflectance at the wavelengths of green light, so the leaf is reflecting mostly green light and appears green to our eyes. The spectrum for the red leaf is highest at the wavelengths of red light, so it reflects mostly red light and appears red to our eyes.

2. Now ask youth to refer to the figure on p. 8 in their Science Notebooks showing the spectrum of Olivine, a mineral found in volcanic rocks on Earth and Mars.

   » Ask youth to make observations about the spectrum and predict what color they think olivine would look like to the eye. Compare Olivine's spectrum on p. 8 of the Data Packet to that of the green leaf on p. 7 of the Science Notebook. Although the scales and graphs are different, both have the highest peak in the visible spectrum (the only part our eyes can see as indicated with the rainbow) in the green part, so they both probably look green.

3. Hand out to each group one copy of the Mineral Fingerprints Data Sheet.

   » Point out the olivine minerals on the fingerprint sheet: they are green!

   » Reiterate that a spectrum shows how much light is reflected at each color (or wavelength). Point out that the rainbow on each plot on the Mineral Fingerprints sheet shows the range of light that the human eye can see, but the spectrometer sees many other types of light that our eyes cannot detect, like ultraviolet and infrared.

   » Optional: Give youth time to look at the other minerals on the fingerprint sheet and compare their spectra to their colors in the pictures.

      » Point out the type of material - clay, volcanic, sulfate

Explore Spectrometry Data (10 min)

1. Pass out the Spectroscopic Data Packets to each group. Tell youth that CRISM is a spectrometer on-board the Mars Reconnaissance Orbiter.

2. Tell youth that they will now use spectroscopy to help them find the best landing site on Mars. They should look for water-related minerals like clays and sulfates, that might indicate evidence of past water (and therefore habitability).

3. Explain that each patterned area on the CRISM Data images in their data packets has a corresponding spectrum.

4. Ask youth to turn to p. 9 in their Science Notebooks and read the directions. They will compare the spectra for each site to the Mineral Fingerprints Data Sheet.

5. Invite groups to write the minerals found at each site in the table on p. 9 in their Science Notebooks and rank the sites based on which sites show the most water-related minerals.

   » Optional: To make this activity more challenging, rather than simply tallying the number of water-related minerals, have youth consider which minerals the rover could actually access from a safe landing ellipse and which might be too far away or in places with dangerous topography.

   » Volcanic minerals are also interesting in this scenario, because they can be analyzed to tell how old the rocks are.

Notes: These patterned areas are idealized and simplified, but in most cases, they are based on actual CRISM observations of these locations on Mars. The minerals listed really are at these locations! They are based on actual CRISM observations of these locations on Mars.

"Spectra" is the plural form of "spectrum"

Reflect (5 min)

1. Summarize by going through each site and leading a discussion about which minerals are present. Which sites do youth think might have once had water based on the minerals detected? *See table below for educator reference but do not show it to youth until after Activity 4.*

2. Let youth know that next time, they will put together everything they have learned from their explorations of Mars and choose a site for the rover to land.

Site	Minerals (water-related minerals are underlined)
Gale	Olivine, Nontronite, Kieserite
Jezero	Olivine, Pyroxene, Kaolinite, Magnesite
Nili Fossae	Olivine, Pyroxene, Nontronite
Iani Chaos	Pyroxene, Kieserite