Educator Guide

# Science Activity 7: Hidden Minerals: Using Spectroscopy to Understand Mars

## Educator Preview

### Activity Snapshot

Learners interpret spectra to identify water-based minerals at potential Mars landing sites.

### Timing | 45 minutes

| | |
|---|---|
| Get Ready and Team Up | 10 min. |
| Analyze Mars Landing Sites | 25 min. |
| Reflect | 10 min. |
| **Total** | **45 min.** |

**Level Up Activities** 20 min. each

### Prep Snapshot*

**Prep Time 50 min.**

At least two days ahead, create tactile spectra graphs and allow them to dry.

Determine how learners will access audio files.

**See Materials & Preparation for full info.*

### 21st Century Skills

**Connection**

- Critical Thinking

**Science Practices**

- Analyzing & Interpreting Data

## Guiding Question

*How can identifying minerals help us choose a landing site on Mars?*

### Learners Will Do

Interpret spectra to identify minerals on Mars that have formed in water.

### Learners Will Know

Scientists can identify materials by looking at their spectra.

### Connecting Across Activities

| Activity 6: Understanding Spectroscopy | Activity 7: Using Spectroscopy to Understand Mars | Activity 8: Choosing a Landing Site and Preparing for the Science Share-Out |
|---|---|---|
| **Last time**, learners learned how to interpret spectra of light reflected from various objects, which will later help them identify minerals from a distance. | **Today**, learners interpret spectra to identify the types of minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site. | **Next time**, they will use the various kinds of data they have collected–landform images, topographic maps, and spectra–to choose a landing site. |

### Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

**QR Code for Activity Resources**

weblink: https://hov.to/2acd78e1

## Materials and Preparation

### Materials

#### For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
- Science Activity 7 Audio Files (weblink)
- 6 audio player(s) with headphones (or learners' personal devices)
- Wipes to clean headphones after each use (if using)
- School glue or puff paint (optional)
- Sand or glitter (optional)
- Computer with internet access (optional)
- 3 copies of each image in Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)
- 3 additional copies of spectra pages in *Science Activity 7 Mars Minerals Spectroscopy Data Packet* (if planning to make Tactile Spectra Models)
- 6 copies of Science Activity 7 Mineral Fingerprints Handout (PDF)
- 6 additional copies of spectra pages in *Science Activity 7 Mineral Fingerprints Handout* (if planning to make Tactile Spectra Models)
- 1 copy of Mineral Station Signs, pgs. 89-91 (3 signs per station)

#### For each learner

- Science Notebook (PDF)

Optional: Printed swell paper (weblink) or assembled tactile models:

- 3 copies of tactile model of *Electromagnetic Spectrum*, pg. 8, in the Science Notebook (PDF) from Activity 3.
- 3 copies of tactile models of Gale Crater Data (4 spectra) , pgs. 4-7 from the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) (12 total spectra models)
- 3 copies of tactile models of Jezero Crater Data (3 spectra) , pgs. 10-12 from the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) (9 total spectra models)
- 6 copies of tactile spectra models, odd-numbered pages 1-11, of Science Activity 7 Mineral Fingerprints Handout (PDF) (6 spectra models per station; 36 total spectra models)

## Activity 7 Materials Preparation (60 min., at least two days ahead)

### Ahead of Time

1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. See Mineral Fingerprints Station Assembly Instructions, pg. 88 for instructions on setting up the tactile and audio stations.
3. Determine how learners will access the audio files on the day of the activity. You have the option to download the audio files (weblink) for each spectrum or use the provided QR codes or links to the files if you plan to have learners access via group or personal devices.

### Teaching Tip

Activity Stations will run concurrently, three stations for each landing site (Gale Crater and Jezero Crater). Each site will include visual graphs (spectra), audio files, and optional tactile graphs (spectra) for each of the minerals in *Science Activity 7 Mineral Fingerprints Handout*. Ensure there are enough materials at each station for one group of four.

To reduce the amount of color printing, you (or learners) can color in the visible light spectra on the graphs.

If you are not planning to make tactile graphs, or if you are printing them on swell paper (weblink), you do not need the two-day waiting period and can prepare closer to the start of this activity.

4. Make copies of Science Activity 7 Mineral Fingerprints Handout (PDF), Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF), and the Science Activity 7 Mineral Station Signs, pgs. 89-91. Note: Data Packets are large (1-5 MB) files. Download and print these ahead of time.
5. Print, fill, and copy a Science Activity 7 Share-Out Invitation Handout, pg. 92 for each learner to send home at the end of the Activity in preparation for the Science Share-Out in Activity 9.

### In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally. Add a section divided into two columns. Title one column "Gale Crater" and the other "Jezero Crater."

### Level Up!

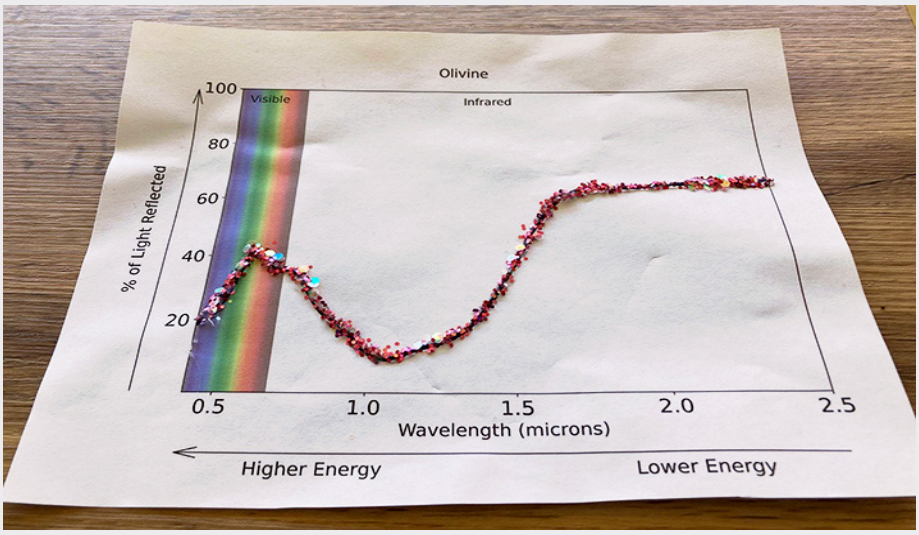
Although this activity lists two possible landing sites, if you have time, the activity is more interesting and enriching with four choices that were all considered by NASA for the Perseverance Rover. To use the additional landing sites, use the advanced Science Activity 7 Mars Minerals Spectroscopy Data Packet with Level Up (PDF) and Science Activity 7 Level Up Audio Files (weblink). Add columns titled "Nili Fossae" and "Iani Chaos" to the *Our Ideas* poster.

## Support Learner Differences

### *Tactile Versions of the Spectra*

Although it is listed as optional, like Activity 6, learners will benefit from interacting with a **tactile version of the spectra**, and it will make for a more enriching experience. See Activity 6 Materials Preparation on pg. 70.

You will need to create 21 tactile spectra: three copies each of pgs. 4-7 and 10-12 in the *Science Activity 7 Mars Mineral Spectroscopy Data Packet*. You will also need to create tactile spectra of the six known minerals, the odd-numbered pages 1-11 in the *Science Activity 7 Mineral Fingerprints Handout*. Ideally, you will provide one tactile copy of the entire *Science Activity 7 Mineral Fingerprints Handout* per station, but one or two tactile versions of this resource could be shared among stations. If appropriate, solicit help.




*A tactile version of olivine's full spectrum with glitter*

# Activity Guide

## Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We learned that scientists learn about materials using the light reflected off them. We practiced interpreting spectra using our eyes and our ears, including the spectrum of a mineral called olivine.)* Refer to the terms related to spectra on the *Our Ideas* poster.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**
3. Say: **Today we'll continue to focus on what Mars is made of to determine whether water was once there.** Refer to the questions on the *Our Ideas* poster about what the planet is made of and what rocks and minerals are present to indicate the presence of past water needed for life. If learners do not mention water, ask them what types of things NASA is interested in learning about Mars and why. It is important they focus on water for the rest of the activity. Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can identifying minerals help us choose a landing site on Mars?**
4. Organize learners into groups of four and distribute Science Notebooks.

### Support Learner Differences

- If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).
- If prepared, distribute tactile models of *Electromagnetic Spectrum*, pg. 8, *Comparing Green Things–Visible*, pg. 12, and *Comparing Green Things–Visible and Infrared*, pg. 13, in the Science Notebook (PDF).

## Analyze Mars Landing Sites (25 min.)

5. Say: **Turn to *Electromagnetic Spectrum*, page 8 in your Science Notebook (PDF).** Give learners a few minutes to review, noticing the visible and invisible portions. Say**: The electromagnetic spectrum includes both visible and invisible light from the Sun.**
6. Say: **Turn to *Green Paint* and *Red Paint,* pages 9-10 in your Science Notebook (PDF)**. Give them a few minutes to review and reorient how to interpret the graphs.
7. Say: **Those spectra were two colors of the same material–paint. Spectrometers were engineered to help scientists identify different types of materials. Turn to *Comparing Green Things–Visible*, page 12 in your Science Notebook (PDF)**. Allow groups a few minutes to notice differences and similarities. Ask: **In the visible spectrum, how does the leaf spectrum compare to the olivine spectrum? What color will these appear to human eyes?** *(The visible spectra are very similar–they all reflect the most green light and will appear different shades of green to human eyes).*

### Support Learner Differences

Play the audio files for Activity 6: Green Paint, Red Paint, and Olivine - visible only (weblink).

Say: **Sometimes materials have very similar spectra in the visible range so they look the same to humans. It might be very difficult for scientists to tell these two materials apart, just by looking at their spectra.**

8. Say: **Remember from the *Electromagnetic Spectrum*** pg. 8**, there are colors of light humans can't see. Spectrometers measure infrared light. It is invisible, so it does not affect the colors humans see, but it is important for identifying materials. Turn to *Comparing Green Things–Visible and Infrared*, page 13. Notice the reflection lines don't stop in the visible part of the spectrum. They keep going to the right of red.** Ask: **How does the olivine spectrum compare to the green leaf spectrum in infrared light?** *(They were very similar in visible light, but they have very different spectra in infrared light.)* **That's why scientists examine spectra that include more than just visible light when they are trying to identify materials.**

9. Say: **Spectrometers measure both visible and invisible light reflecting off objects to create spectra like these. Every material has a one-of-a-kind spectrum. That means the shape of spectra can be used like fingerprints to identify unknown materials. As scientists, we can interpret the shapes of different spectra and match them to the shapes of spectra from the laboratory to identify unknown materials.**

10. Say: **Engineers designed a spectrometer that is onboard a spacecraft orbiting Mars. The spectrometer has measured the visible and infrared light reflecting off minerals at each landing site location. You are now ready to interpret these spectra to find out if there are any minerals that form in water at each of the possible landing sites.**

11. Explain the Site Data Stations:
    - Demonstrate as you say: I have set up stations around the room. Each station represents a landing site, Gale Crater or Jezero Crater. Your notebook includes QR codes to audio files (weblink) for each landing site and spectra of different minerals.
    - Show learners the ***Science Activity 7 Mineral Fingerprints Handout*** as you say: This is a list of minerals and how they form. Some of these minerals form in water, indicated by a water droplet, and some do not. When you get to a station, preview the ***Mineral Fingerprints*** pages. You will need to find the minerals that form in water, because these will provide evidence of habitability. Demonstrate by finding the information on the first fingerprint page.

### Support Learner Differences

Play the audio files for Science Activity 7: Green Leaf (weblink), and Olivine (weblink).

### Level Up!

Show the video Why Do Scientists Need to Measure Infrared Light? (5 min.)

Some animals can see colors of light that humans can't, and vice versa. If learners are interested in how different animals see color differently, point them to the RadioLab episode "Rippin' the Rainbow a New One." (20 min.)

### Support Thinking

Show the video How We Use Spectroscopy to Learn About Other Planets to help learners understand how spectroscopy is used to identify minerals on planets like Mars.

- Show learners the ***Science Activity 7 Mars Minerals Spectroscopy Data Packet*** as you say: Each site also includes a map showing the location of some unknown minerals at that landing site. Your task is to use the audio files and/or spectra to identify the unknown minerals at each site. As you investigate, fill out Minerals We Notice, pg. 14 in your Science Notebook (PDF).

12. Invite learners in groups of four to visit each Site Data Station and use spectroscopy data to identify the unknown minerals. As they work, remind them to look for minerals that form in water because they might indicate evidence of past liquid water (and therefore habitability).

13. As learners explore, ask: **What do you gain by identifying minerals using audio as compared to the visual and tactile models?** *(It is easier to notice certain aspects of the data in one form rather than another.)*

14. When they have finished exploring, invite small groups to share their observations of the minerals at each site with the entire group. Record them on the *Our Ideas* poster. Ask: **Using the information you gathered about minerals, which sites do you think might have had water in the past?** *(Both sites have minerals that form in water.)* Say: **With your group, rank the sites based on the number of water-based minerals present at each site.**

### Support Thinking

Remind learners to trace what the pitch of the sound is doing with their finger on the table while they listen to the audio.

### Teaching Tip

You can have groups stay together or have members split up and go to different stations.

Suggest roles that group members can fill, such as referring to observations, moderating discussion, and recording the group's choices.

### Support Thinking

If learners are having trouble interpreting the spectra, emphasize that each material has a one-of-a-kind spectrum. Although it is better if learners understand what the graphs are showing, this activity still works as a simple matching exercise: to identify the mineral, find the spectrum with the same shape.

### Teaching Tip

Refer to the following list of minerals at each site but do not share it with learners:

**Gale Crater:** Mineral 1 is nontronite (forms in water), mineral 2 is kieserite (forms in water), mineral 3 is gypsum (forms in water), mineral 4 is olivine.

**Jezero Crater:** Mineral 1 is pyroxene, mineral 2 is kaolinite (forms in water), mineral 3 is olivine.

The patterned areas on the mineral maps in the *Science Activity 7 Mars Minerals Spectroscopy Data Packet* are idealized and simplified, but they are based on actual observations of these locations on Mars. The minerals listed really are at these locations!

## Reflect (10 min.)

15. Revisit the Guiding Question on the *Our Ideas* poster: Ask: **How can identifying minerals help us choose a landing site on Mars?** *(Spectroscopy data can show us minerals that form in water, which means liquid water was at a location in the past. That location would be a good landing site.)*

### Level Up

To make this activity more challenging, have learners consider which water-based minerals the rover could reasonably access from a safe landing oval, and which minerals might be too far away or in places with dangerous topography.

16. Ask: **When might measuring reflected light (spectroscopy) help us?** *(Paint color matching; at crime scenes; identifying crops or minerals on Earth, etc.)* Consider returning to learners' ideas at the start of the next activity.

17. Say: **Spectroscopy is used to identify unknown materials on Earth, on other planets, and in distant galaxies. This tells us something important about the universe: it is all made of the same stuff and science works the same everywhere. We can use our knowledge of science and engineering on Earth and know that it also applies to everywhere else in the universe!**

18. Ask: **What questions do you still have?** If there are unanswered questions on the *Our Ideas* poster, encourage learners to do some research on their own using these resources:
    - https://science.nasa.gov/mars/facts/
    - https://mars.nasa.gov/#red_planet/0
    - https://en.wikipedia.org/wiki/Mars

19. Say: **Good job working as scientists today! Now you are prepared for next time, when you will put together all the information you have gathered to choose a site for the rover to land on Mars. Remember, the process you are following is like the process NASA uses to choose landing sites.**

## After the Activity

1. Clean up:
    - Keep the *Our Ideas* poster for use in Activity 8.
    - Collect the supplies from each station: audio player, *Science Activity 7 Mars Minerals Spectroscopy Data Packet* and tactile graphs, *Science Activity 7 Mineral Fingerprints Handout* and tactile graphs, and *Science Activity 7 Station Signs*. Save for use in future activities.
2. Plan ahead for Science Activity 8. See Activity 8 Materials Preparation, pg. 94.
3. Take time to reflect on the following educator prompt: **How did you help learners apply what they learned about minerals and light in the previous activity?**

## Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

# Mineral Fingerprints Station Assembly Instructions

There will be six stations that run concurrently, three stations for each landing site (Gale Crater and Jezero Crater).

Each of the materials lists below is for one setup; however, to accommodate 24 learners, each landing site station needs three setups. Prepare and include the tactile spectra models with each station, (see Advance Preparation, pg. 82, Support Learner Differences) with each station, if you think learners would benefit from these.

To assemble each station, arrange all the materials for a station on a table or desk, leaving room for learners to move between the stations.

## Gale Crater Station materials for one setup:

- Science Activity 7 Mineral Fingerprints Handout (PDF)
- Science Activity 7 Mineral Fingerprints Data Audio Files (weblink) (if not using QR codes on *Science Activity 7 Mineral Fingerprints Handout* - 6 files)
- Science Activity 7 Mars Minerals Spectroscopy Data Packet
- Science Activity 7 Gale Crater Unknown Minerals Audio Files weblink (if not using QR codes on *Science Activity 7 Mars Minerals Spectroscopy Data Packet* - 4 files)
- Optional:
  - Tactile versions of *Science Activity 7 Mars Minerals Spectroscopy Data Packet*
  - Tactile model of *Science Activity 7 Mineral Fingerprints Handout*
- Gale Crater station sign
- audio player with headphones
- cleaning wipes

## Jezero Crater Station materials for one setup:

- Science Activity 7 Mineral Fingerprints Handout (PDF
- Science Activity 7 Mineral Fingerprints Data Audio Files (weblink) (if not using QR codes on *Mineral Fingerprints Handout* - 6 files)
- *Mars Minerals Spectroscopy Data Packet*
- Science Activity 7 Jezero Crater Unknown Minerals Audio Files (weblink) (if not using QR codes on *Science Activity 7 Mars Minerals Spectroscopy Data Packet* - 3 files)
- Optional:
  - Tactile versions of *Science Activity 7 Mars Minerals Spectroscopy Data Packet*
  - Tactile model of *Science Activity 7 Mineral Fingerprints Handout*
- Jezero Crater station sign
- audio player with headphones
- cleaning wipes

### Teaching Tip

If learners have their own devices and headphones and access to the internet, you have them scan the QR code to each audio file. You could also provide links to the audio files and use a computer or tablet. Find a quiet area for the audio stations, if possible.

## Mineral Station Signs

GALE CRATER

GALE CRATER

## Mineral Station Signs

GALE CRATER

JEZERO CRATER

## Mineral Station Signs

JEZERO
CRATER

JEZERO
CRATER

## Science Share-Out Invitation

# You're invited to the Science Share-Out

*Come see your young scientist showcase their Mars Rover Landing Site!*

**Date:** _____

**Time:** _____

**Location:** _____

Grantee