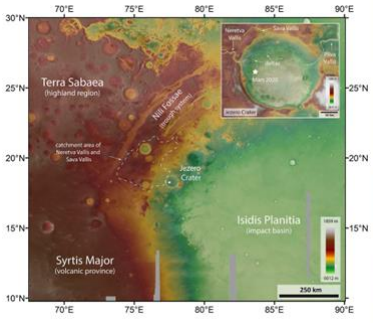
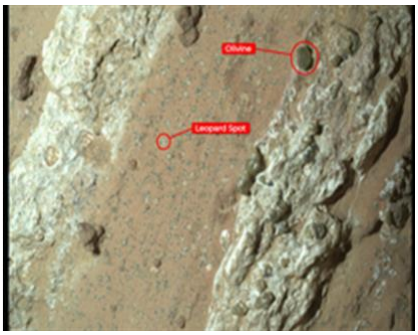
Sapphire Canyon and the Search for Ancient Life
Mars Exploration Classroom Guide

In Reference to:

Worlds Beyond and Astrobiology Insights - Blog #15

Click here to read the Blog





Grade Level: 5 - 12
Estimated Time: 90 - 120 minutes (Length will vary)
Learning Objectives:

- Understand what biosignatures are and why they matter
- Explore the geology of Mars and how scientists study it
- Analyze real-world discoveries using scientific reasoning
- Engage creatively with the concept of life beyond Earth

Teaching Tips

- Begin with vocabulary to build foundational understanding
- Use the reading passage to guide inquiry-based discussion
- Encourage creativity through storytelling or comic drawing
- Integrate math with graphing and data analysis
- Use hands-on modeling to reinforce abstract concepts
- Facilitate group discussion with open-ended prompts
- Adapt activities for different grade levels or time constraints

Educational Standards and Core Requirements: See page 11

Section 1: Vocabulary Builder

Match each term with its correct definition.

Term	Definition Letter
Biosignature	
Vivianite	
Greigite	
Jezero Crater	
Perseverance	

Definitions:

A. A mineral often found near decaying organic matter
B. NASA's rover exploring Mars since 2021
C. A crater on Mars that once held a lake
D. A clue that may suggest past or present life
E. A mineral linked to microbial activity in water

Section 2: Science in Action

Passage:

After reading the blog entitled: **"Sapphire Canyon and the Strongest Evidence Yet of Ancient Life on Mars"**, consider this passage and answer the questions below. In 2025, NASA scientists confirmed that a rock sample called Sapphire Canyon contained organic molecules and minerals like vivianite and greigite. These are considered biosignatures -- possible signs of ancient life. The sample was collected from Jezero Crater, a place that once had flowing water.

Questions:

1. Why is Jezero Crater a good place to look for signs of life?
2. What makes vivianite and greigite important in the search for life?
3. Why do scientists need to bring samples back to Earth?

Section 3: Compare and Reflect

Mission	Year	Discovery Type	Confidence Level
Viking	1976	Soil reactivity	Low
Curiosity	2012	Organic molecules	Moderate
Perseverance	2025	Biosignatures in rock	High

Reflection Prompt:

Which mission do you think made the biggest impact and why?

Section 4: Creative Challenge

Imagine you're a Martian microbe living in Sapphire Canyon 3 billion years ago. Write a short story (150–200 words) or draw a comic strip showing what your life might have been like. Include:

- What you "eat"
- What your environment looks like
- How scientists might discover you today

Section 5: Extension Activity

Title: *Mars vs. Mars: Comparing Ancient Environments*

Objective:

Students will research another scientifically significant location on Mars and compare it to Jezero Crater, focusing on habitability, geology, and biosignature potential.

Step-by-Step Instructions:

REFER to Mars Maps Provided on pages 8 & 9

1. **Choose a Comparison Site (Use Mars Landing Maps Provided)**
   Select one of the following (or another site of interest):
   - Gale Crater (explored by Curiosity)
   - Elysium Planitia (InSight lander)
   - Oxia Planum (future ESA mission)
   - Gusev Crater (Spirit rover)
   - Hellas Basin (ancient impact site)

2. **Research Your Site**
   Use NASA's Mars mission pages, planetary science articles, or curated classroom resources to gather:
   - Age and geological history
   - Evidence of water (past or present)
   - Types of minerals or soil detected
   - Any signs of organic molecules or biosignatures
   - Which rover or lander explored it (if any)

3. **Mars Crater Comparison Chart: Jezero vs Your Chosen Site**

   See this chart which is below the Mars Landing Map Page and use that. Found on Page 9

Category	Jezero Crater	My Chosen Site
Location		
Age (in billions of years)		
Evidence of Water		
Key Minerals Detected		
Organic Molecules Found		
Biosignature Potential		
Rover Mission		

4. **Using this Chart Create a Mini-Poster**
   Include the following sections using the internet or library for your research:
   - **Title**: "Jezero Crater vs. [Your Site]"
   - **Location Map**: Show both sites on a Mars map
   - **Geology Snapshot**: Compare terrain and rock types
   - **Water Evidence**: Describe signs of ancient lakes, rivers or ice
   - **Biosignature Potential**: Rate likelihood of past life (Low - Moderate - High)
   - **Fun Fact**: Include one surprising or lesser-known detail
   - **Your Verdict**: Which site do you think is more promising and why?

5. **Present or Share**
   Students can present their posters in small groups or display them in a classroom "Mars Gallery." Optionally, record short video summaries for outreach or science fair use.

6. **Optional Challenge:**

   Write a short proposal to NASA explaining why your chosen site should be the next target for sample return. Include:

   - Scientific justification
   - What instruments you'd send
   - What questions you hope to answer

Section 6: Think Like a Scientist

Scenario:

NASA receives a new rock sample from a dry riverbed near Jezero Crater. It contains traces of sulfur, layered sediments and faint organic compounds. The sample was collected by Perseverance from an area once shaped by flowing water.

Student Challenge:

You are part of a Mars Sample Analysis Team. Your job is to decide whether this sample could contain biosignatures - clues that might suggest ancient life.

- **Part A: Is This a Good Candidate?**

  Prompt:
  Based on what you know about biosignatures, geology and Mars' history, explain why this sample might - or might not - be a strong candidate for biosignature analysis.

  Guiding Questions:

  - What does sulfur tell us about past environments?
  - Why are layered sediments important?
  - Could faint organic compounds be contamination or real evidence?

- **Part B: What Tests Should Scientists Run?**

  Prompt:
  List and describe at least three scientific tests or instruments that could help analyze the sample.

  Examples:

  - **Spectroscopy**: To identify chemical bonds and organic molecules
  - **Microscopy**: To look for microfossil-like structures or textures
  - **Isotope Analysis**: To detect biological fractionation patterns
  - **X-ray Diffraction**: To determine mineral composition
  - **Mass Spectrometry**: To measure molecular weight and structure

  Encourage students to explain what each test reveals and why it matters.

- **Part C: What Might These Clues Suggest?**

  Prompt:

  Based on the results of your proposed tests, what might scientists conclude?
  Students should consider multiple possibilities:

  - Evidence of ancient microbial life
  - Abiotic (physical and not related to biological) chemical processes that mimic biosignatures
  - Preservation of organic material in a once-habitable environment
  - Need for further testing back on Earth

  Optional Extension: Team Debate

  Split students into two groups:

  - **Group A** argues the sample shows signs of ancient life
  - **Group B** argues the sample is inconclusive or abiotic
    Each team presents evidence, counters arguments, and defends their conclusion.

Section 7: Graphing Extension

Use Graphing Sheet on page 10 and copy as needed

Title: *Tracking Clues to Ancient Life on Mars*

Objective:

Students will analyze hypothetical biosignature data from three Mars locations, graph the results, and interpret which site may offer the strongest evidence for ancient life.

Step-by-Step Instructions:

1. Introduce the Concept

Explain that biosignatures - such as organic molecules, specific minerals, or isotopic ratios - can vary in concentration depending on the location and geological history of a site.

2. Provide Hypothetical Data Table (This is found underneath the graphing sheet)

Location	Organic Molecules (ppm)	Greigite (mg/kg)	Sulfur Isotopes (‰)
Jezero Crater	15	4.2	-1.5
Gale Crater	9	2.8	-0.7
Elysium Planitia	5	1.1	-0.2

Note: ppm = parts per million; ‰ = per mil (isotopic deviation)

3. Graphing Task

Three blank graph templates for students to plot biosignature concentrations across Mars locations:

1. **Organic Molecules (ppm)**
   - Y-axis: Concentration from 0 to 100 ppm
   - X-axis: Location A, B, C
   - Space for bar or line plotting
2. **Greigite (mg/kg)**
   - Y-axis: Concentration from 0 to 50 mg/kg
   - X-axis: Location A, B, C
   - Designed for mineral comparison
3. **Sulfur Isotopes (‰)**
   - Y-axis: Isotopic deviation from 0 to 10‰
   - X-axis: Location A, B, C
   - Ideal for interpreting biological fractionation

Students will:

- Create a **bar graph** for each biosignature type
- Use color coding for each location
- Label axes clearly (e.g., “Organic Molecules (ppm)” vs. “Mars Location”)
- Optionally, create a **composite graph** showing all three biosignatures per site

4. Analysis Questions

After graphing, students answer:

1. Which location shows the highest concentration of organic molecules?
2. Which site has the strongest greigite signal?
3. What might the sulfur isotope values suggest about biological processes?
4. Based on all three biosignatures, which site seems most promising for ancient life and why?

Optional Extension:

Have students calculate a simple “biosignature index” by assigning scores to each category (e.g., 1 - 5 scale) and averaging them to rank the sites.

Discussion:

If you were leading a future Mars mission, which site would you choose to explore next and what instruments would you bring?

Section 8: Discussion Prompts

- What counts as life?
- Should we send humans or robots to explore Mars?
- How would discovering ancient life change our view of Earth?

Section 9: Hands-On Extension

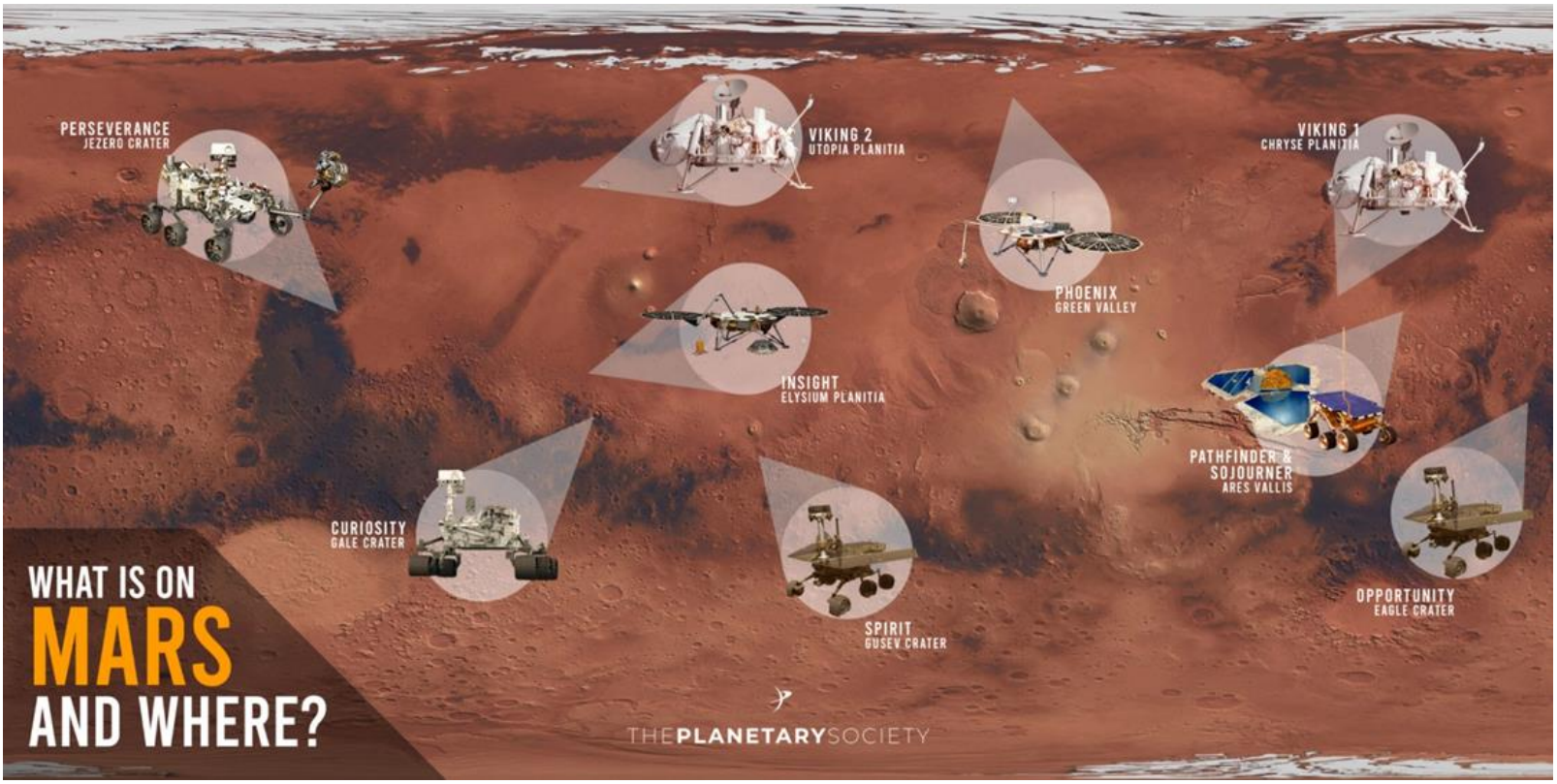
Title: *Exploring Rocks Using Core Sampling*

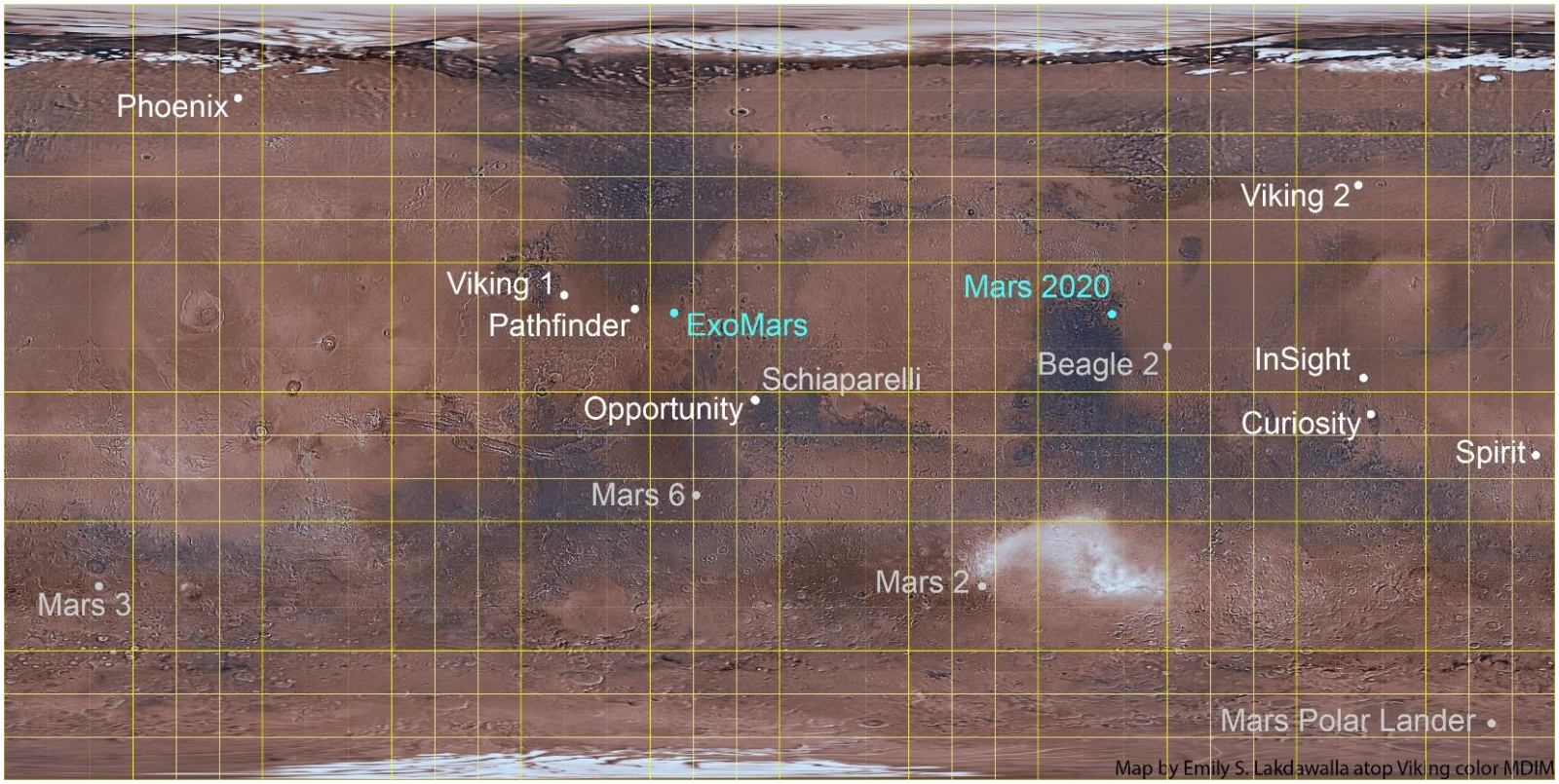
Objective:

Students will simulate how scientists use core samples to investigate minerals and organic compounds which can lead to the possible detection of life or past life on Mars.

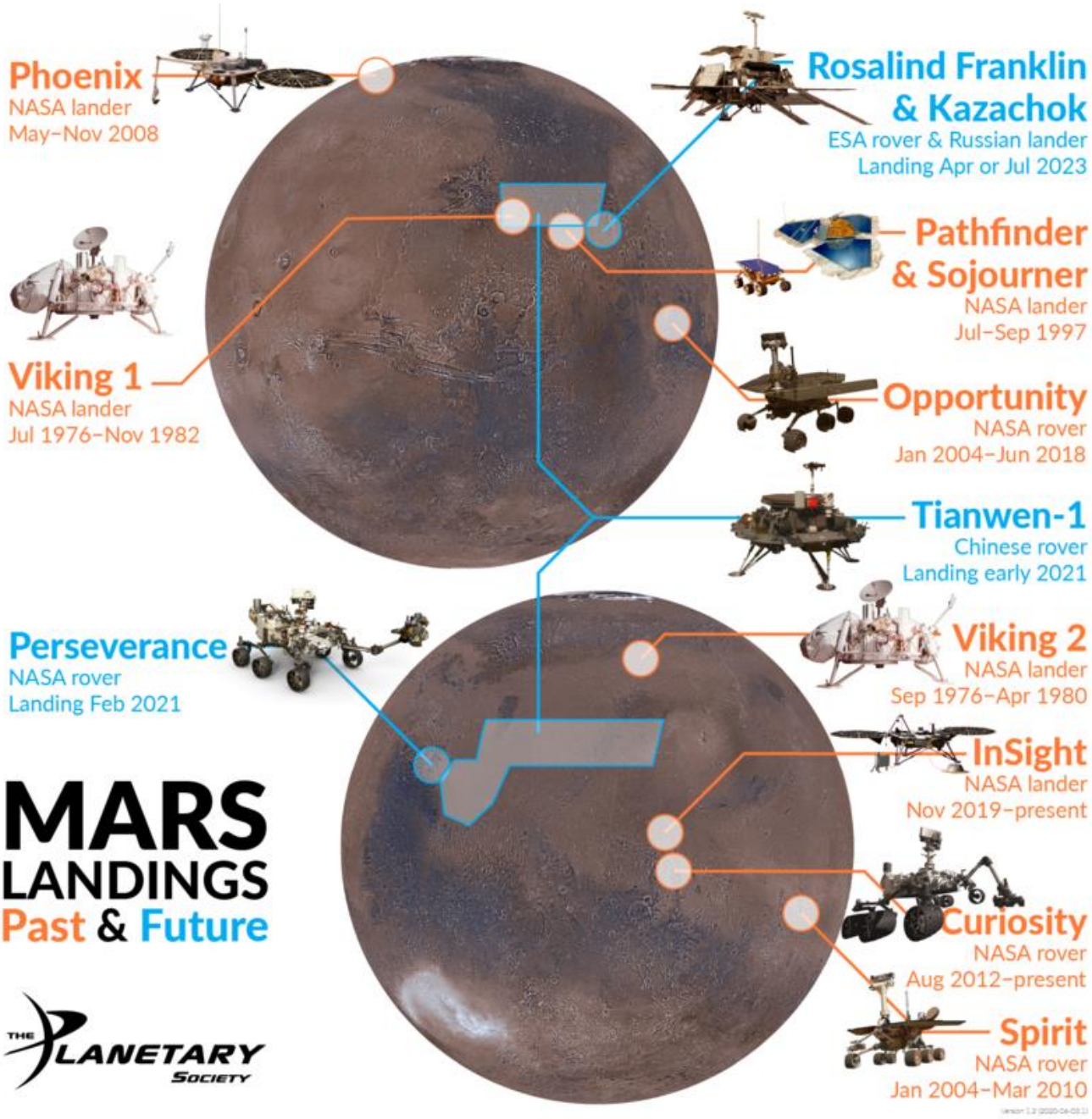
Click on the link to go to the activity: **https://tinyurl.com/4c5hvkvz**

MARS LANDING MAPS 1





MARS LANDING MAP 2



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Age (in billions of years)		
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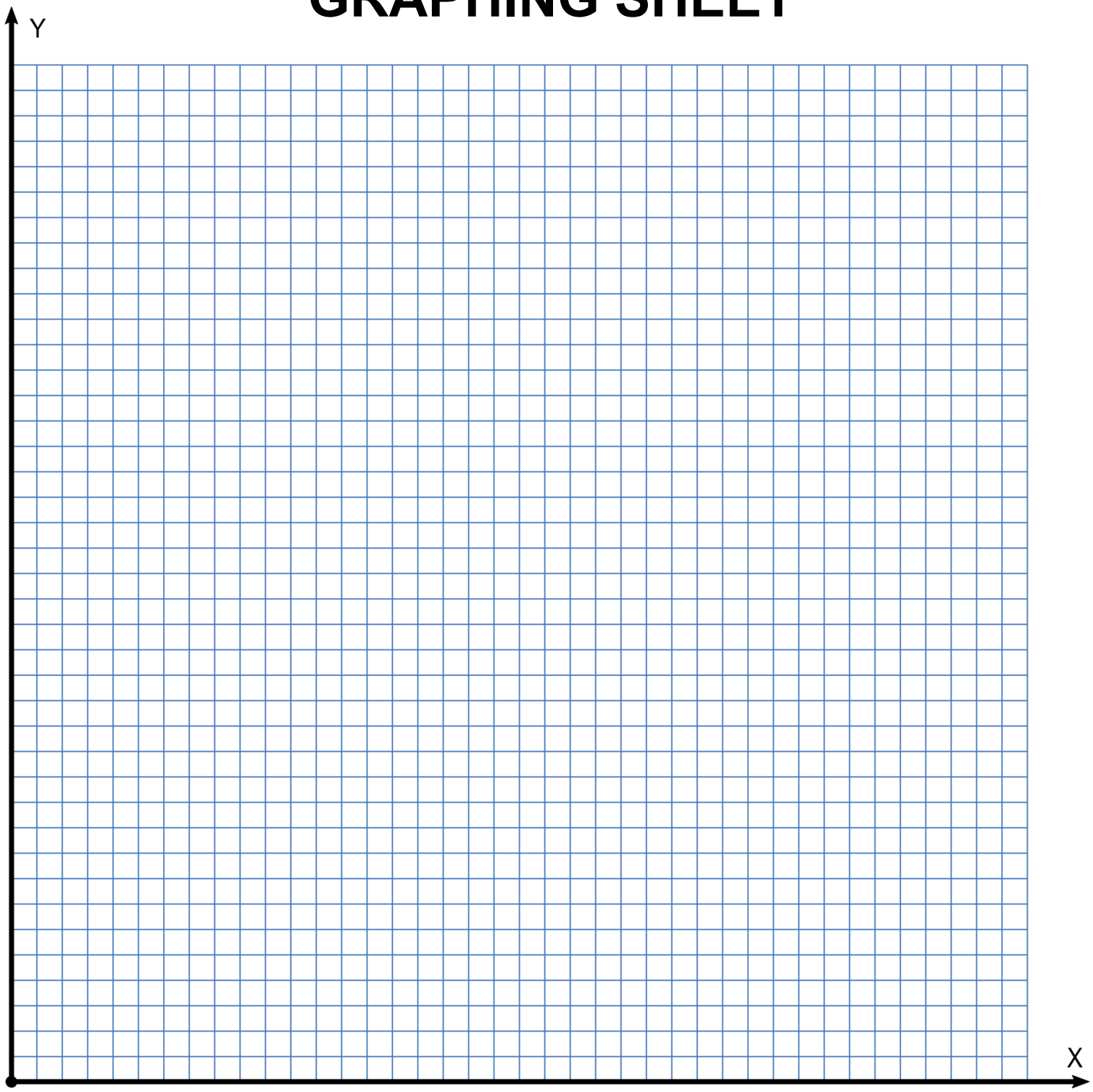
Key Minerals Detected		
Organic Molecules Found		
Biosignature Potential		
Rover Mission		

GRAPHING SHEET



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Standards Alignment Summary for Grades 5 - 12

Next Generation Science Standards (NGSS)

Earth and Space Science (ESS):

- **ESS1.A: The Universe and Its Stars**
- **ESS1.B: Earth and the Solar System**
- **ESS2.C: Roles of Water in Earth's Surface Processes**
- **ESS2.D: Weather and Climate**
- **ESS3.A: Natural Resources**
- **ESS3.C: Human Impacts on Earth Systems**

Life Science (LS):

- **LS1.C: Organization for Matter and Energy Flow in Organisms**
- **LS2.A: Interdependent Relationships in Ecosystems**
- **LS4.D: Biodiversity and Humans**

Engineering, Technology, and Applications of Science (ETS):

- **ETS1.A: Defining and Delimiting Engineering Problems**
- **ETS1.B: Developing Possible Solutions**
- **ETS1.C: Optimizing the Design Solution**

Crosscutting Concepts:

- **Patterns**
- **Cause and Effect**
- **Systems and System Models**
- **Energy and Matter**
- **Structure and Function**
- **Stability and Change**

Science and Engineering Practices:

- **Asking Questions and Defining Problems**
- **Planning and Carrying Out Investigations**
- **Analyzing and Interpreting Data**
- **Constructing Explanations and Designing Solutions**
- **Engaging in Argument from Evidence**

Common Core State Standards (CCSS)

English Language Arts (ELA):

- **RI.5–12.1: Cite textual evidence to support analysis**
- **RI.5–12.7: Integrate information from diverse formats**
- **W.5–12.2: Write informative/explanatory texts**
- **SL.5–12.1: Engage in collaborative discussions**
- **SL.5–12.4: Present claims and findings clearly**

Mathematics:

- **5.MD.B.2: Represent and interpret data**
- **6.SP.B.4–5: Summarize and describe distributions**
- **7.RP.A.2: Recognize and represent proportional relationships**
- **HSN.Q.A.1–3: Use units to solve problems**
- **HSS.ID.A.1–3: Summarize, represent, and interpret data**

Answer Key

Section 1: Vocabulary Builder

- Biosignature → D
- Vivianite → A
- Greigite → E
- Jezero Crater → C
- Perseverance → B

Section 2: Science in Action

1. It once had flowing water and sedimentary rock.
2. They're minerals linked to biological processes.
3. Earth labs have better tools for detailed analysis.

Section 3: Compare and Reflect

Open-ended—look for reasoning tied to discoveries and confidence levels.

Section 6: Think Like a Scientist

Part A: Yes, sulfur and sediment suggest water and potential life.

Part B: Tests: spectroscopy, microscopy, chemical analysis.

Part C: All possibilities are correct and should be discussed

Section 7: Graphing Extension

Students should identify the site with highest biosignature concentration and justify why it's promising.

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