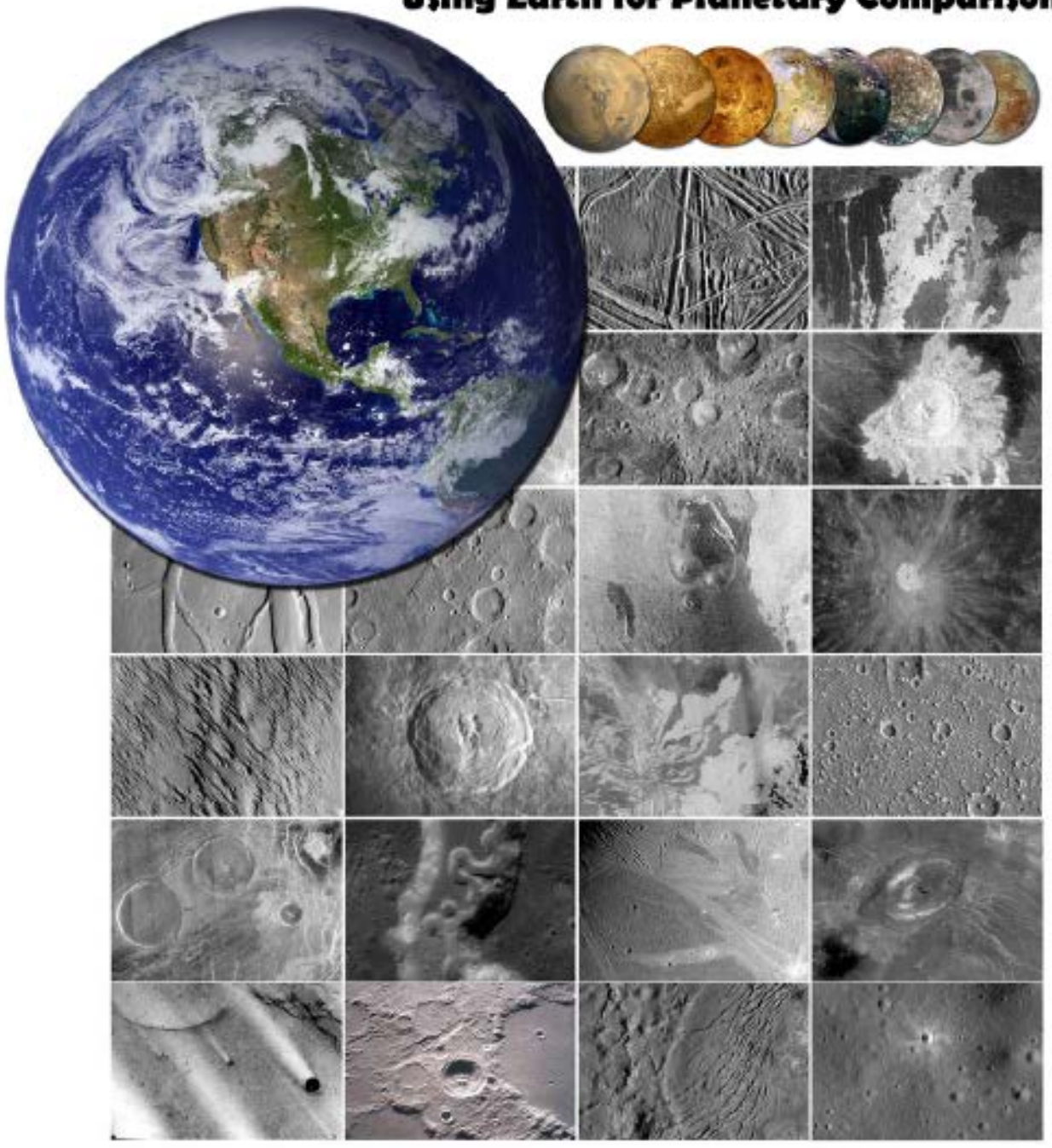
National Aeronautics and
Space Administration

Blue Marble Matches

Using Earth for Planetary Comparisons



STUDENT GUIDE

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National Aeronautics and Space Administration

Blue Marble Matches

Using Earth For Planetary Comparisons

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Using Earth for Planetary Comparisons

Student Name: _____

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PART 1: Observations & Descriptions

NASA explores planetary bodies, including Earth, to better understand the Solar System in which we live. Various types of spacecraft and scientific instruments are used to explore and gather data. Scientists use the data returned from these spacecraft to make observations which they record, analyze, and interpret. One technique or process of gathering data from a distance using spacecraft, or even aircraft, is called remote sensing. Remote sensing allows you to gather data of a location you might not be able to visit in person.

One application of remote sensing is using images to identify geologic features on different planets. How do scientists determine what geologic features exist on other planets? This activity will help you understand part of that process. It starts with making good observations, being descriptive, and using what we know about Earth. For the first part of this activity, we will test your skills in how observant and descriptive you can be. The remote sensing images of Earth you will observe in this activity were taken by astronauts from the International Space Station or Space Shuttle using hand held cameras.

Directions:

1. Given one image per group from the ***BMM Explore Cards***, OBSERVE and DESCRIBE in the space below.
    a. As you write your description, do not name features or objects in the image. Instead, use descriptive words to describe what you see.
    b. Someone will attempt to identify the image you describe.

IMAGE DESCRIPTION **Use descriptive words to describe your image. Do not name features or objects.**

2. Class Discussion: As a class, view all 8 images.
    a. When called upon, read the group description to the class to see if they can correctly identify the image.
    b. Discuss how the group could improve image description.

3. Based upon the class discussion, list 3 to 5 useful characteristics or ways to describe features in images.

Useful Characteristics
A.
B.
C.
D.
E.

4. Class Discussion: Description Characteristics.

What are these images all about? They are remote sensing images of Earth that focus on features related to four different geologic processes that help shape the surface of our planet. These processes are related to wind, water, volcanoes, and impacts (meteors striking the surface).

5. Class Discussion: Earth Processes and Geologic Features

6. Examine all 8 images shown on the ***BMM Explorer Cards***. Complete the table below.
    a. List which images match the given geologic process you think created the features shown in the images.
    b. Explain the WHY. What is your reasoning for why you match an image to a process?
    c. Attempt to name the feature in each image.

GEOLOGIC PROCESS	**IMAGES** *(Use numbers 1-8)*	**WHY** *(Reasoning)*	**FEATURE NAME** *(Optional)*
AEOLIAN (WIND)			
FLUVIAL (WATER)			
VOLCANIC			
IMPACT			

Now that you have an idea of how you can be descriptive and have some thoughts about the geologic processes related to the images you observed, let's investigate further.

- Did you know the names of these geologic features?
- Do you know how they form?
- Are these same features found on other planets in our solar system?
- How do scientists use what they know about Earth to explore other planets?

This activity will help you understand and answer these questions. Let's explore!

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PART 2: Identification Criteria

You will now make observations of other astronaut photographs of Earth. Your logged observations of these images will help you learn to identify specific features associated with different geologic processes (aeolian, impact, fluvial, and volcanic). The feature charts you will examine include images grouped by process. Information is included on the back of each image to help you. As you make observations, think about how each feature is formed and be prepared to select and create identification criteria for each feature in the tables below.

Directions:

1. Use the ***BMM FEATURE CARDS EARTH*** to help you identify the geologic feature that goes with the 4 different geologic processes (Aeolian, Fluvial, Volcanic, Impact).
    a. Each card is organized by process. The back of the card identifies the geologic feature, the location of the picture and other visible features shown in the pictures.
2. Make observations of the different geologic features visible in the images on the feature chart.
3. In the tables below, use 2 check marks for each column to indicate which 2 criteria best describe each feature. Make changes or adjustments to listed criteria if you wish.
4. Create your own descriptions that can be used as other identification criteria for each feature.

AEOLIAN PROCESSES Features created by or associated with the effects of WIND			
IDENTIFICATION CRITERIA	**SAND DUNES**	**WIND STREAKS**	**YARDANGS**
Looks like a smear across the surface			
Has a ripple-like appearance			
Look “cut into” the surface forming crisscrossing or parallel lines.			
Sand-sized particles closely grouped together on the surface			
Look like a series of grooves scratched into the surface			
Look like a faint mixture of light or dark smudges on the surface			
Other:			
Other:			
Other:			

FLUVIAL PROCESSES Features created by or associated with the effects of WATER			
IDENTIFICATION CRITERIA	**CHANNEL**	**DRAINAGE NETWORK**	**DELTA**
Feature has a very dendritic-like pattern; similar to the vein-like pattern within a leaf			
Long extended feature that curves or meanders through an area; sometimes has 2 or 3 smaller channels connected to it			
Long windy feature that sometimes contains features such as U-shaped oxbow lakes, meander scars or tear-drop shaped island(s)			
Has a fan-like or triangular shape			
Sometimes looks like a triangle or birds foot where sediment is built up and deposited			
Numerous small channels or tributaries that feed into larger channels or valleys			
Other:			
Other:			
Other:			

IMPACT PROCESSES Features created by or associated with a METEOR striking the surface	
IDENTIFICATION CRITERIA	**IMPACT CRATER**
Circular feature that sometimes has a raised rim and a smooth, flat floor	
Flat, roundish feature that looks eroded and is sometimes filled in or outlined by water	
Other:	
Other:	
Other:	

VOLCANIC PROCESSES Features created by or associated with VOLCANIC Activity			
IDENTIFICATION CRITERIA	**VOLCANO**	**CENTRAL VENT/CALDERA**	**LAVA FLOW**
Looks similar to an impact crater and is circular in shap			
An entire structure that includes a circular opening at the top and has flanks or sides			
An entire structure that may look raised and have a cone or dome or steeple-like shape			
Channel-like flow or fingery appearance with uneven edges			
Single or multiple circular depressions at the center or top of valcano			
Flow-like material that appears to be darker than surrounding surface			
Other:			
Other:			
Other:			

PART 3: Feature Recognition and Review

The identification criteria you just developed should help you recognize these different geologic features in other images with confidence. You must use those criteria to support your identification of these features. Feel free to refine or add to your criteria as you continue with this activity. In order to help reinforce and review your feature recognition skills you will receive a new set of images to observe.

Directions:

1. Open the ***BMM EARTH FEATURE REVIEW IMAGES***. Use the cards to complete the table below as you make observations of the images. In the table below you will:
    a. List identification criteria for the main feature shown in the image.
    b. Name the main geologic process that helped form that feature.
    c. Based on your listed criteria, name the main geologic feature that best matches.

2. As you discuss your answers, you may experience how scientists (both professionals and students) do not always agree! Scientific debate and using evidence to back up interpretations are key elements of science.
    a. Be open to changing your original identification of a feature if you can be convinced. It is not all about what answer is right or wrong. More importantly, it is about evidence that support your interpretation.
    b. Not all scientists agree, which is an important aspect of how science progresses.

IMAGE #	IDENTIFICATION CRTERIA (List specific criteria from your Identification criteria table)	MAIN GEOLOGIC PROCESS (Aeolian, Fluvial, Volcanic, Impact)	MAIN GEOLOGIC FEATURE
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			

PART 4: *Using Earth for Planetary Comparisons*

You are now ready to use what you have learned and apply it to identifying geologic processes and features on other bodies in the solar system.

Directions:

1. Open the BMM FEATURE CARDS PLANETARY.
2. Each group will examine the features for MARS and another solar system object of choice to include the MOON, VENUS, MERCURY and JOVIAN MOONS. Also, open the BMM PLUTO 2-1-16 Cards
3. Fill out all 3 tables below for the planetary body image chart (Mars, Pluto & Group Selection).
    a. Use the identification criteria you developed and refined for features on Earth. You must use those criteria as evidence to support your identification of these features.
    b. If there are characteristics that do not match your criteria for the feature on Earth or if you are making observations that cause you to be unsure about the identification of the feature, be sure to list those in the table.
    c. Based on your observations and how well your criteria match a given feature, list your level of confidence in the last column. Be ready to defend your identification or discuss your uncertainty.
    d. As you discuss your answers, you will likely experience again how scientists do not always agree! Remember, scientific debate and using evidence to back up your interpretations are key elements of science. It is not all about what answer is right or wrong. More importantly, it is about evidence and criteria that support your interpretation!

PLANETARY BODY NAME: MARS					
IMAGE # (use image #'s 1-8 or 9-16)	**IDENTIFICATION CRITERIA** (List specific criteria from your Identification criteria table)	Characteristics that DO NOT match Identification Criteria or Observations that Decrease Level of Confidence (If Any)	**Main Geologic Process**	**Main Geologic Feature**	**Level of Confidence** 1=Not Confident 2=Somewhat Confident 3=Totally Confident

PLANETARY BODY NAME: PLUTO					
IMAGE # (use image #'s 1-8)	**IDENTIFICATION CRITERIA** (List specific criteria from your Identification criteria table)	Characteristics that DO NOT match Identification Criteria or Observations that Decrease Level of Confidence (If Any)	**Main Geologic Process**	**Main Geologic Feature**	**Level of Confidence** 1=Not Confident 2=Somewhat Confident 3=Totally Confident

PLANETARY BODY NAME: _____					
IMAGE # (use image #'s 1-8)	**IDENTIFICATION CRITERIA** (List specific criteria from your Identification criteria table)	Characteristics that DO NOT match Identification Criteria or Observations that Decrease Level of Confidence (If Any)	**Main Geologic Process**	**Main Geologic Feature**	**Level of Confidence** 1=Not Confident 2=Somewhat Confident 3=Totally Confident

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PART 5: Observations, Interpretation and Drawing Conclusions

As you can probably tell, planetary bodies are affected by similar processes that help shape the surface of Earth. Some processes, however, seem to be more (or less) dominant than others.

I. Some planetary bodies have tons of impact craters, others have few. Some have evidence of wind, water, or volcanic features, others do not. Which planetary body is most like Earth? Which is least like Earth?

II. If you only made observations of one planetary body, how is it similar or different from Earth? What do these similarities and differences mean?

III. Based on your observations, what can you infer about these planetary bodies? These are important questions that are an important part of the process of science.

As part of that process, all scientists make observations and interpret those observations to gain a better understanding and draw conclusions about what they are researching. Observations are general trends, patterns, or descriptions that almost everyone can agree upon. Interpretations are what you think those observations may mean. Interpretations, as you should already know, can vary from scientist to scientist, but are based on supporting evidence. Throughout this activity you have already been making observations and interpretations. Your observations were the identification criteria you used to describe features in images. Your interpretations included naming the geologic feature you felt best matched your criteria.

Similar to what professional scientists do, you will now take this idea of observations and interpretations to the next level. Scientists use initial observations and interpretations to help raise their level of understanding. As they make additional observations and learn more, they can use this new knowledge to make more advanced interpretations and draw conclusions or make inferences.

Directions:

1. For this part of the activity you will revisit and review observations and interpretations you have already made. You will then extend that information using the knowledge you have gained and additional observations you have made. This will allow you to advance your interpretations and draw conclusions or make inferences about what you have learned.
2. As you fill out information in the table on the next page, consider the following:
    a. OBSERVATION: List a specific planetary body and include one observation you made. Your observation should be the specific identification criteria used to identify a specific feature.
    b. FEATURE INTERPRETATION: Based on the identification criteria, name the feature that best matches. If there can be a potential misinterpretation or confusion between what the feature may be, include information to help you interpret the feature consistently.

c. ADDITIONAL OBSERVATIONS: Log additional observations you made of images in Part 4. If you found additional information about the planetary body from other sources (books, the internet), it's a good idea to get into the habit of referencing those sources.

d. ADVANCED INTERPRETATIONS: Your additional observations and background knowledge gained from this activity and other sources of information should allow you to list advanced interpretations. These advanced interpretations allow you to make deeper connections that will help you make inferences or draw conclusions. As with all parts of the process of science, you must have evidence to support your interpretations and conclusions. Interpretations can change as you gain more knowledge.

e. CONCLUSIONS/INFERENCES ABOUT PROCESSES THAT SHAPE THE SURFACE: The information you include here are your conclusions or inferences about processes that shape the surface of the particular planetary body.

3. Log at least 3 observations, interpretations and conclusions. Your logged information should support the conclusions and inferences you make about processes that shape the surface of the planetary body/bodies you have observed.

OBSERVATION (List specific criteria from your Identification criteria table)	**FEATURE INTERPRETATION**	**ADDITIONAL OBSERVATION** (List Additional Observations)	**Advanced Interpretation**	**CONCLUSIONS/INFERENCES** (About the processes that shaped the surface)
PLANETARY BODY MARS **OBSERVATION** *There are circular depressions on the surface.*	*These circular depressions could be volcanic craters or impact craters. When they are not part of a raised structure, they are most likely impact craters.*	• *Impact crater rims appear to be worn down.* • *Rims do not always appear as perfect circles.* • *There appears to be evidence of wind related features (wind streaks and sand dunes) in and around impact craters.* • *Mars is a dusty planet.*	• *Dust and sand are likely carried by the wind and can either erode the surface or be deposited on the surface.* • *Impact craters have likely been affected by these processes.*	• *Mars must have an atmosphere since there is evidence of aeolian processes.* • *Wind has eroded the surface of Mars in its past and may still be changing the surface today.* • *Dust and sand likely erode the surface.* • *The atmosphere is thick enough to have wind but not thick enough to prevent meteors from striking the surface.*
PLANETARY BODY **OBSERVATION**				

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OBSERVATION (List specific criteria from your Identification criteria table)	**FEATURE INTERPRETATION**	**ADDITIONAL OBSERVATION** (List Additional Observations)	**Advanced Interpretation**	**CONCLUSIONS/INFERENCES** (About the processes that shaped the surface)
PLANETARY BODY **OBSERVATION**				
PLANETARY BODY **OBSERVATION**				

You have made observations and interpretations that have allowed you to draw conclusions and make inferences about the planetary bodies you investigated. These terrestrial worlds or rocky planets all have a lithosphere/geosphere – they have rocks. Did any other planetary body you observed also have an atmosphere? Do any of them have a hydrosphere? How do we go about detecting if any of them have a biosphere? If you remember, the different Earth systems (litho/geosphere, atmosphere, hydrosphere, and biosphere) are all connected and combined make up our unique planet. The interaction of different systems on other planetary bodies likely play a role in the past, present, and future of these bodies, just as they do on Earth. There is so much yet to be discovered!

As the exploration of Earth and other planetary bodies in our solar system continues and new discoveries are made, scientific progress and our understanding of our solar system deepens. What we learn today may be refined tomorrow. This makes science an ever-changing and dynamic discipline. You are encouraged to follow along with NASA's journey of exploration or even better yet, become a part of it. NASA needs the next generation of scientists and engineers to help continue the exploration of Earth and beyond. That next generation of explorers includes you!