Select a Landing Site

Suggested Grade Level: 3–9

Summary

- Students will work in a team to choose a landing site for a future mission to Mars.
- Students will review the advantages and disadvantages of six selected sites on Mars.
- Students will discover that there is always risk involved in planetary missions no matter which site is chosen.

Standards

- NM State Science Content Standards: Strand III, Science and Society
- National Science Education Standards: Standard G, History and Nature of Science

Background Information

There is always a balance in selecting a landing site for a mission to another planet. The scientists want to go to a scientifically interesting site; the engineers point out that it doesn't matter how interesting a site is if the lander crashes on landing. This is one reason that rover missions are favored: the landing site can be safe and flat and relatively uninteresting and the rover can travel to a more interesting location. Within the science community there is also debate about landing sites. Some scientists may want to go to an area that represents typical terrain, and others may want to go to a region of unusual or unique terrain. The landing site may also be selected on the basis of the particular scientific questions that the mission intends to study. For example, two very different landing sites might be selected depending on whether the mission is designed to look for evidence of past water or to examine volcanoes. The landing site may also be chosen on the basis of the technology of the mission. For example, the airbag landing technology used for the Pathfinder and the Mars Exploration Rover (MER) missions required a flat landing site with very few large rocks and located at a particular elevation range.

The Mars Exploration Rover (MER) Mission landing sites were selected after two years of study and analysis and after review of almost 200 possible sites. The qualifications included sites that were near the equator (to take advantage of maximum solar power), low in elevation, not too steep, not too rocky, not too dusty, and showing possible evidence of past water. Initially, four sites were chosen, two primary (Gusev Crater and Meridiani Planum) and two backup (Isidis Planitia and Elysium Planitia). To give you an idea of how sites are analyzed, here are the advantages (pros) and disadvantages (cons) listed by the scientists studying each of these sites.

Gusev Crater (15 degrees S, 175 degrees E). Pros: Water channels appear to flow into crater; appearance of layered sedimentary deposits. Cons: windy area; layers could be formed by impact or volcanic airfall or deposited by wind as well as water.

Meridiani Planum (3 degrees S, 353 degrees E). Pros: chemical presence of iron mineral hematite, which usually forms in the presence of water. Cons: Hematite can form in other ways too; the site is very flat and featureless.

Isidis Planitia (5 degrees N, 88 degrees E). Pros: Highland–lowland boundary; many drainage channels in area, assumed to be region of water-altered rocks. Cons: Rocky area.

Elysium Planitia (12 degrees N, 124 degrees E). Pros: Well-known and reliable landing site; least windy site. Cons: Not very interesting scientifically.

Materials

- Select a Landing Site on Mars Data Sheet, included in this activity
- Six images of sites on Mars with advantages (pros) and disadvantages (cons) for each site, included in this activity
- Six cards with mission scenarios/results, included in this activity
- Certificate for mission participants, included in this activity
- One die (a single dice) or spinner wheel or some other way of randomly selecting a number from 1 to 6

Preparation

1. Print out copies of each of the site images and their pros and cons. Cut out the pros and cons for each site; they can be pasted to the back of each site image or given to a team after they have selected a site. Each team can work with a set of all six images or each team can be given only two or three sites to decide between.

2. Acquire a die or spinner wheel or set up another technique to randomly select a number from 1 to 6.

3. Print out the six scenarios/results and cut them out as separate pieces of paper or glue them to index cards with the numbers 1–6 printed on the back of each card.

4. Print and photocopy several copies of the Select a Landing Site Data Sheet for each team.

5. Print or photocopy a certificate for each student.

Introduction for Students

Choosing a landing site on another planet can be very difficult. If you were an alien scientist studying Earth and could choose only one landing site, where would you go? Would you choose a typical place on Earth or an unusual place? Would you choose on the basis of scientific interest or safety? Similarly, if you had to choose only one place on Mars that you would like to explore, where would you go? And remember, this mission may succeed or fail based on your choice! Safe landing sites are often uninteresting to the scientists or the general public but still have scientific merit. Very interesting (geologically) sites such as canyons or volcanic craters can be extremely difficult and dangerous but can offer more data for the scientists. And, all planetary landings are potentially dangerous no matter how well-planned they are.

Procedure

1. Give each team images and one-sentence descriptions of sites on Mars. Select any number (2 to all 6) of the following for each team: Valles Marineris, Tempe Fossae, Daedalia Planum, Apollinaris Patera, Arsia Mons, and Parana Vallis.

2. Each team should make observations about the surface of Mars as depicted in these sites. What type of terrain is depicted (valley, plains, volcano, multiple valleys or ridges and grooves)? What kind of science could be done at this site?

3. Each team should use the Select a Landing Site on Mars Data Sheet in order to rank each of their sites for safe landing, geological features, and any special advantage.

4. Each team should choose one of their sites as their landing site, based on the ranking on the Data Sheet(s).

5. After selection of one site, the team should read the pros and cons of landing at that particular site.

6. Each team should select a spokesperson to describe their analysis, their decision, and the pros and cons of their selected site to the class.

7. As the class watches, a representative of each team should roll the die or use another technique to randomly select a number from 1 to 6 and read the matching mission scenario/results (included in this activity) that will enable each team to find out what happened to the mission sent to their site.

Process/Closure

So far, we have only attempted landing at very safe, flat sites on other planets. In the future, more geologically interesting sites (such as the volcanoes or canyons at some of the sites included in this activity) might be selected. The six sites in this activity are among those that have been reviewed by scientists for possible future missions. There is always risk involved no matter how carefully the site is chosen and how carefully the mission is planned.

Extension/Enrichment

Have each team research the name and the general geology of their selected site and prepare a report (oral or written). What kind of mission would be best to send to your selected site: lander, rover, instrument probe, or human mission? Why?

Have students research the Mars Exploration Rover (MER) Mission landing sites in Gusev Crater and Meridiani Planum and the two backup sites in Isidis and Elysium (locations listed above), and rank and compare these sites using the Data Sheet to see if the students agree with the scientists' choice. Have students rank all of the sites (including Gusev and Meridiani and the two backup MER.

This activity can also be a link to a nomenclature activity. Use the information below on Mars nomenclature and have students define their own categories of names for features on Mars (based on ice cream types, famous musicians, etc.). Have the class research planetary nomenclature and generate a list of new names that could be actually submitted to the International Astronomical Union and assigned to individual features on Mars using the information on the web site of the U.S. Geological Survey's Gazetteer of Planetary Nomenclature at http://planetarynames.wr.usgs.gov/.

Credits

This activity was created by Jayne Aubele, New Mexico Museum of Natural History & Science, and Celestyna Brozek, formerly of LodeStar Astronomy Center.

Additional Notes on Mars Nomenclature

All names of landscape features on other planets are assigned and approved by international agreement by the Nomenclature Committee of the International Astronomical Union. Scientists and the general public can submit names to be approved by the committee. Each planet has different categories of feature names that can be assigned. Note that landscape features on Mars are classified by type of landscape such as valleys, mountains, plains, or cliffs, and these are called by Latin words such as vallis (for valley), or mons (for mountain) or planum for plain, or fossae (for cliff). In addition to the basic landscape word, the features

are also given individual names. These names can be submitted by the general public and are also frequently submitted by scientists who are working on the features and want to be able to refer to them by name. The submitted names have to meet certain qualifications and are then approved by the International Astronomical Union. The names come from all of the languages and cultures of Earth. There are specific categories of names that can only be assigned to specific types of features on Mars.

- Albedo features (albedo means dark or light patches on the surface): named for places in classical mythology (most were assigned by the early astronomers Schiaparelli and Antoniadi)
- Large impact craters (craters approximately 60 km and larger): named for deceased scientists who have contributed to the study of Mars; writers and others who have contributed to the lore of Mars
- Small impact craters (craters approximately 60 km and smaller): villages of the world with a population of less than 100,000; note that there is a Santa Fe crater in the Chryse Planitia region of Mars
- Large valles (valleys): the name given to the planet Mars (or the word for red star) in the various languages and cultures of Earth
- Small valles (valleys): classical or modern names of rivers on Earth
- Other features on Mars: named based on a nearby albedo feature that has already been named
- Deimos: all names on Deimos are names of authors who wrote about the martian satellites
- Phobos: all names on Phobos are names of scientists involved with the discovery, dynamics, or properties of the martian satellites

Glossary of Names Used in this Activity

General landscape features on Mars:

- Fossae: Long, narrow, shallow depressions
- Mons: mountain
- Patera: an irregular depression, with scalloped edges, frequently interpreted to be a volcanic crater
- Planum: plateau or high plain
- Vallis: valley (note: vallis is singular, valles is plural)

Individual Examples of the Landscape Features Listed Above

- Apollinaris: from classical Greek mythology
- Arsia: from classical Roman mythology
- Daedalia: from classical Greek mythology
- Marineris: the great equatorial canyon of Mars was named after the first spacecraft ever to orbit Mars and send back images of the canyon (the spacecraft was named Mariner 9)
- Parana: a South American river (from Brazil and Argentina)
- Tempe: Greek valley south of Mt. Olympus noted for its beauty

Mars Landing Sites

Parana Vallis: craters with some water features nearby.

- Pros: Evidence of water (might find fossils?); Relatively safe landing area.
- Cons: If water is the only reason you choose this site and it turns out there is none or if you can't get into one of the channels, the mission might be wasted.

Arsia Mons: a typical large Martian volcano.

- Pros: Interesting rift on its flanks in a line with smaller volcanoes in the crater which may mean relatively youthful volcanism; Would be able to get chemistry of Mars volcanic rocks.
- Cons: Difficult area to traverse with a rover or to land on.

Apollinaris Patera: an older volcano with a different look to it, one of the few volcanoes in the southern hemisphere of Mars.

- Pros: Really unusual volcano, could get chemical composition; Water features nearby and layered material within the crater.
- Cons: Very difficult landing site and terrain for a rover.

Daedalia Planum: flat plains with craters up against older cratered highlands.

- Pros: Flat plain (safe); Lava flows of plains and old cratered highlands would be interesting to look at and analyze for any differences in chemical composition.
- Cons: We think that we already know the composition of the flat plains of Mars; It might be difficult to climb up onto the older cratered highlands if we landed on the plains.

Valles Marineris: a huge canyon system on Mars.

- Pros: Very unique feature; Might find layering in rocks and very old rocks in the walls of the canyons, like Earth's Grand Canyon.
- Cons: Really big feature, we would have to travel a rover a long way to see much of it; Hazardous landing within the canyon.

Tempe Fossae: an interesting plains area broken up by long linear cliffs that are believed to represent faults.

- Pros: Very interesting geologically.
- Cons: Difficult place to land and traverse safely; Just looking at the cliffs might not tell us very much about how they were formed.

Mission Scenario Cards

Mission Scenario #1:

If you roll this number after landing:

You are using airbags as landing technology and they take a really long time to deflate, which delays your travel, but eventually your rover moves off the lander with no problems.

At one site, you discover evidence that appears to indicate that liquid water existed on Mars surface for a long time at that site.

Unfortunately, a freak dust storm lasts several days, coats the rover solar panels, and ends the mission before you can confirm the evidence or look for other evidence.

Mission Scenario #2:

The parachute malfunctions and does not cut itself away from the lander.

The petals of the lander open in such a way that the rover is unable to get off the petals and over the parachute.

The rover part of the mission has failed, the lander is only able to take photos of the landing site area, and the rover cannot travel even to the closest rock.

Mission Scenario #3:

The landing goes smoothly but the small explosives (called pyrotechnic devices) designed to go off to cut the cable attaching the rover to the lander damage one of the cameras on the rover.

Because of the damage to the camera, the rover cannot see the terrain near its left front side. However, everything else works successfully. New rock and soil chemistry is found but there is no evidence of liquid water in the past at this site.

The rover functions for 103 sols (Martian days) and goes a full kilometer away from the landing site showing us a Mars surface that we have never seen before!

Mission Scenario #4

The lander is caught by high winds at the landing site and hits Mars at an angle. Rocks split the airbags and all but one of the instruments on the rover are damaged during landing.

The only instrument that works is a close-up image camera, which takes high-resolution images of rocks and soil.

Mission scientists learn some new things but not as much as they had hoped.

Mission Scenario #5

The rover discovers a new mineral that has high-tech applications for Earth.

Plans are made for a future sample return mission.

Industry is interested in setting up a mining operation and a national debate begins about whether we should mine Mars.

Mission Scenario #6

The rover discovers a rock surface that looks like a fossil in the images returned to mission control.

The science team writes a paper about the discovery and is awarded a special Nobel Prize.

Plans are made for a future mission to follow this incredible discovery.

Mission Scenario #1:

If you roll this number after landing:

You are using airbags as landing technology and they take a really long time to deflate, which delays your travel, but eventually your rover moves off the lander with no problems.

At one site, you discover evidence that appears to indicate that liquid water existed on Mars surface for a long time at that site.

Unfortunately, a freak dust storm lasts several days, coats the rover solar panels, and ends the mission before you can confirm the evidence or look for other evidence.

Mission Scenario #2:

The parachute malfunctions and does not cut itself away from the lander.

The petals of the lander open in such a way that the rover is unable to get off the petals and over the parachute.

The rover part of the mission has failed, the lander is only able to take photos of the landing site area, and the rover cannot travel even to the closest rock.

Mission Scenario #3:

The landing goes smoothly but the small explosives (called pyrotechnic devices) designed to go off to cut the cable attaching the rover to the lander damage one of the cameras on the rover.

Because of the damage to the camera, the rover cannot see the terrain near its left front side. However, everything else works successfully. New rock and soil chemistry is found but there is no evidence of liquid water in the past at this site.

The rover functions for 103 sols (Martian days) and goes a full kilometer away from the landing site showing us a Mars surface that we have never seen before!

Mission Scenario #4:

The lander is caught by high winds at the landing site and hits Mars at an angle. Rocks split the airbags and all but one of the instruments on the rover are damaged during landing.

The only instrument that works is a close-up image camera, which takes high-resolution images of rocks and soil.

Mission scientists learn some new things but not as much as they had hoped.

Mission Scenario #5:

The rover discovers a new mineral that has high-tech applications for Earth.

Plans are made for a future sample return mission.

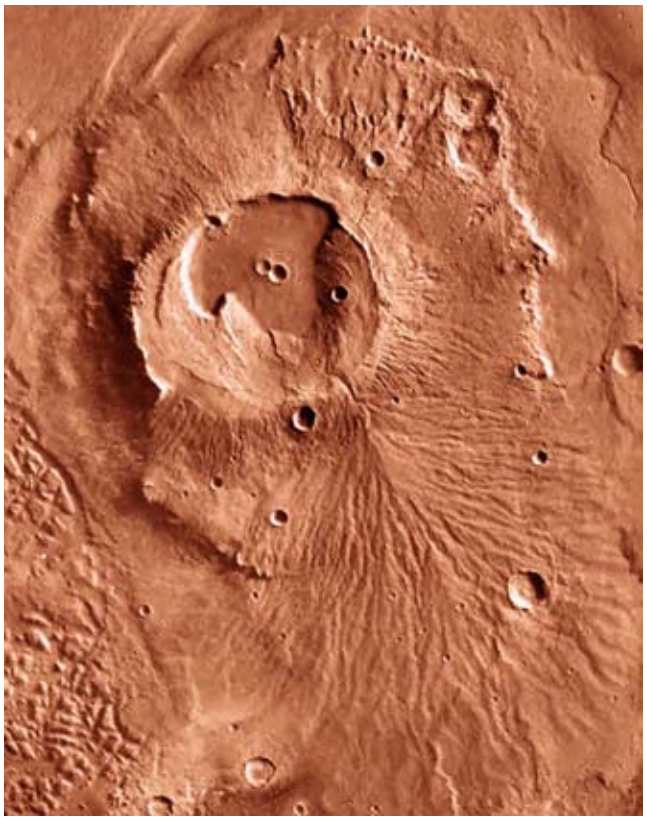
Industry is interested in setting up a mining operation and a national debate begins about whether we should mine Mars.

Mission Scenario #6:

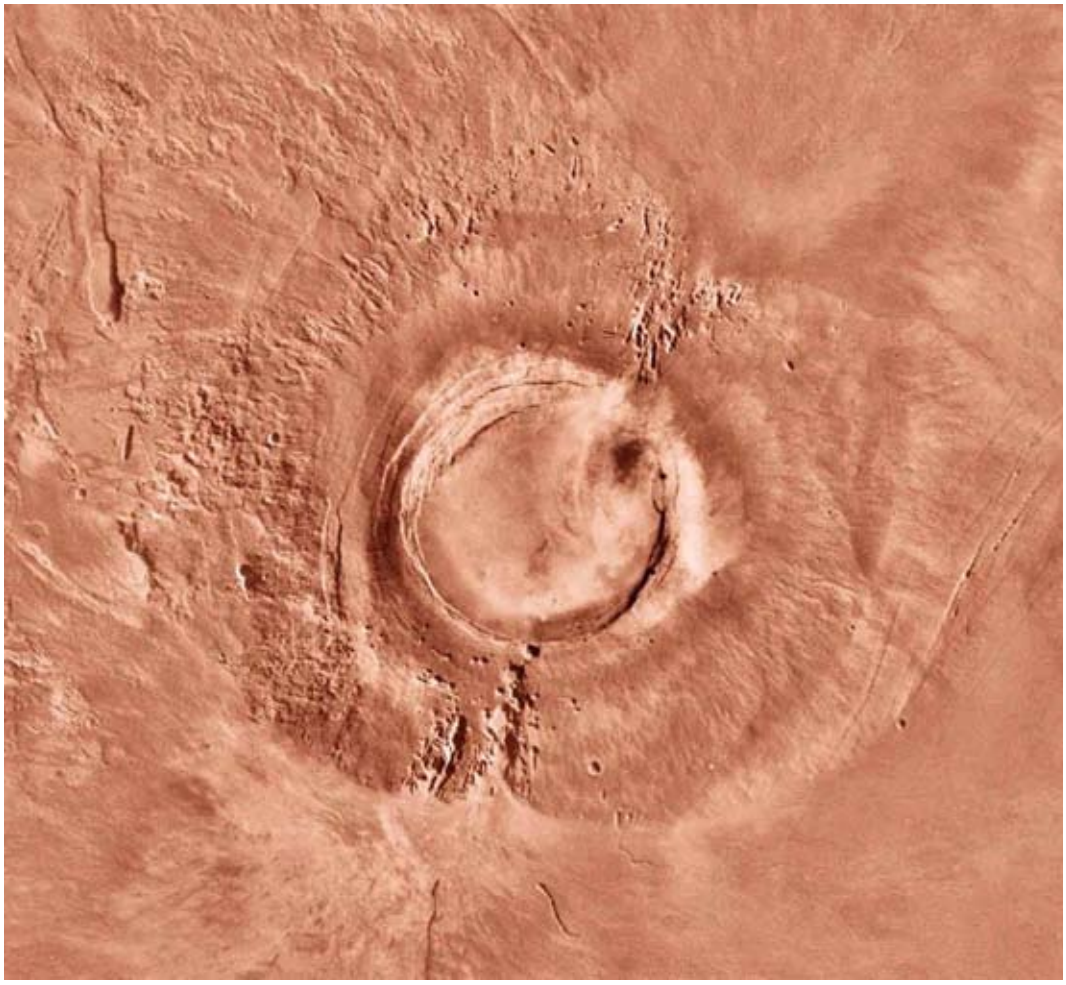
The rover discovers a rock surface that looks like a fossil in the images returned to mission control.

The science team writes a paper about the discovery and is awarded a special Nobel Prize.

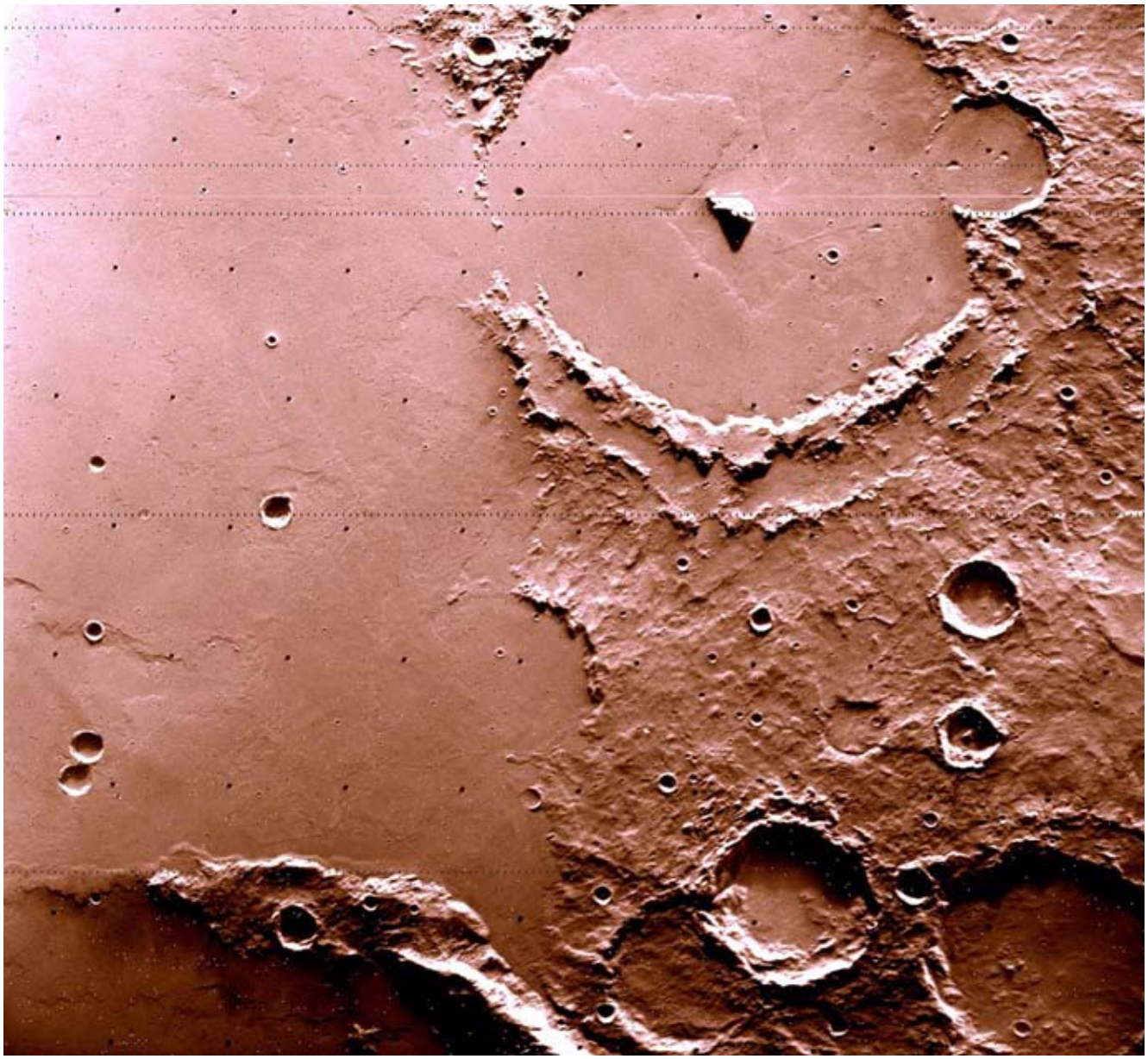
Plans are made for a future mission to follow this incredible discovery.



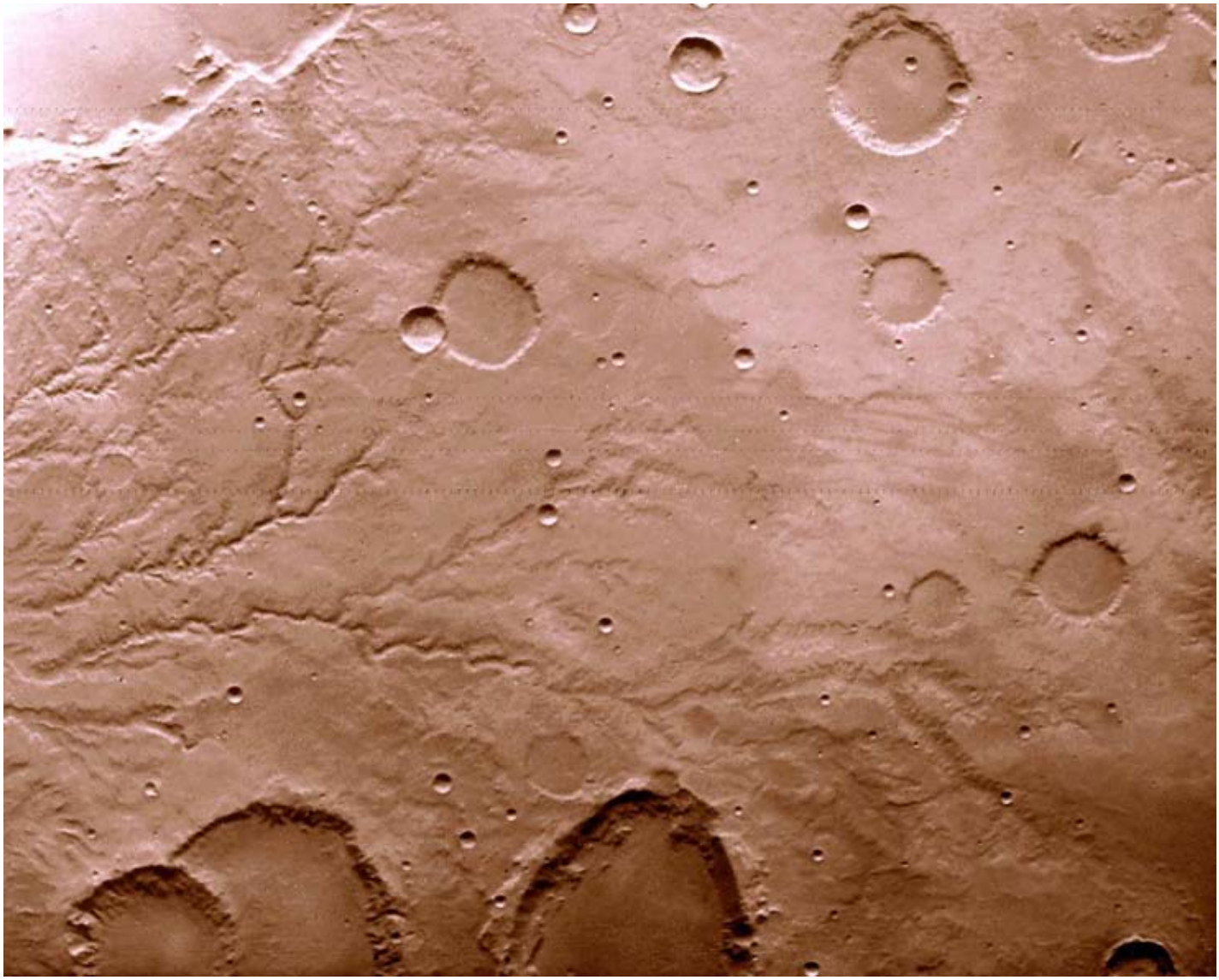
Apollinaris Patera



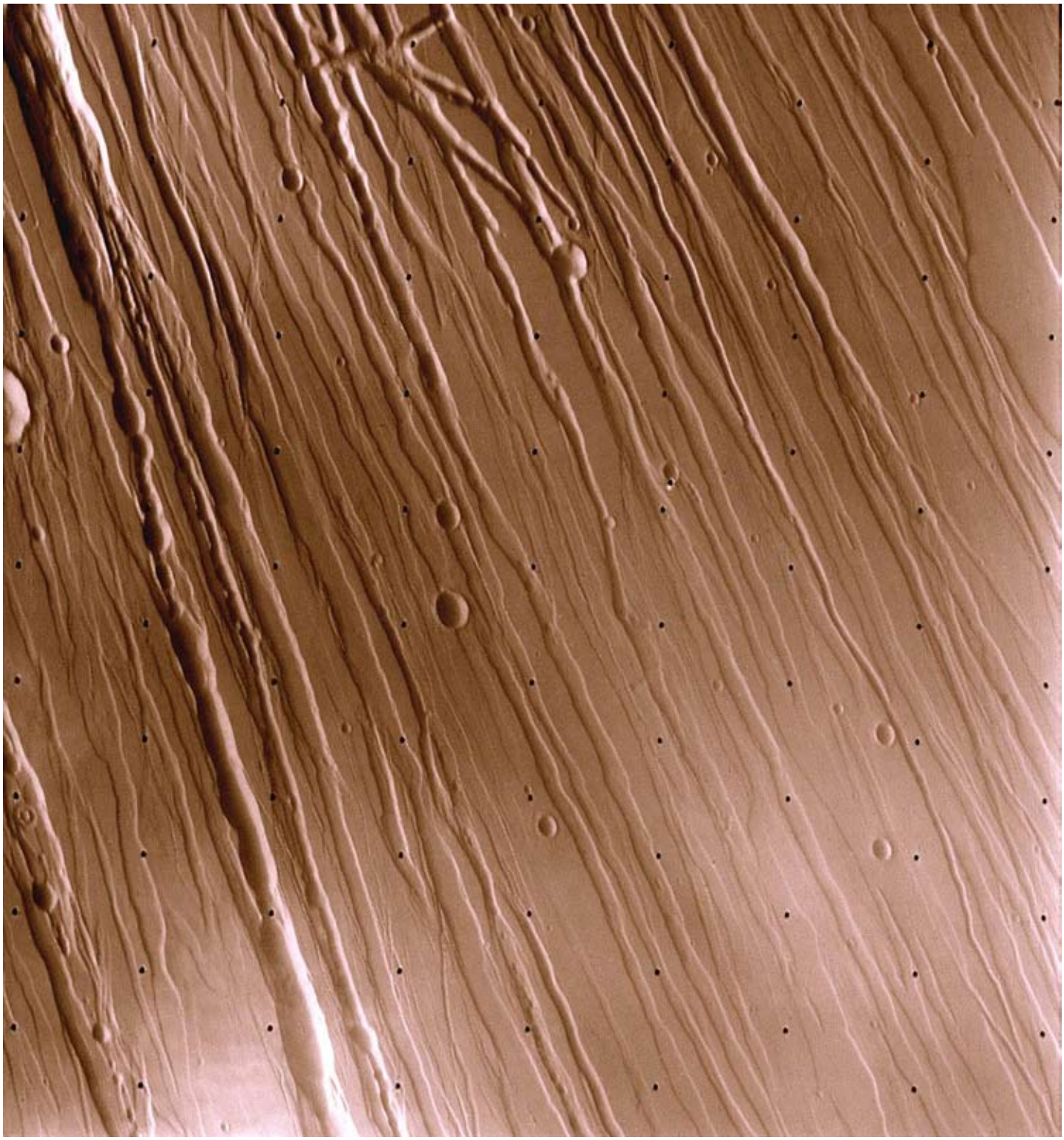
Arsia Mons



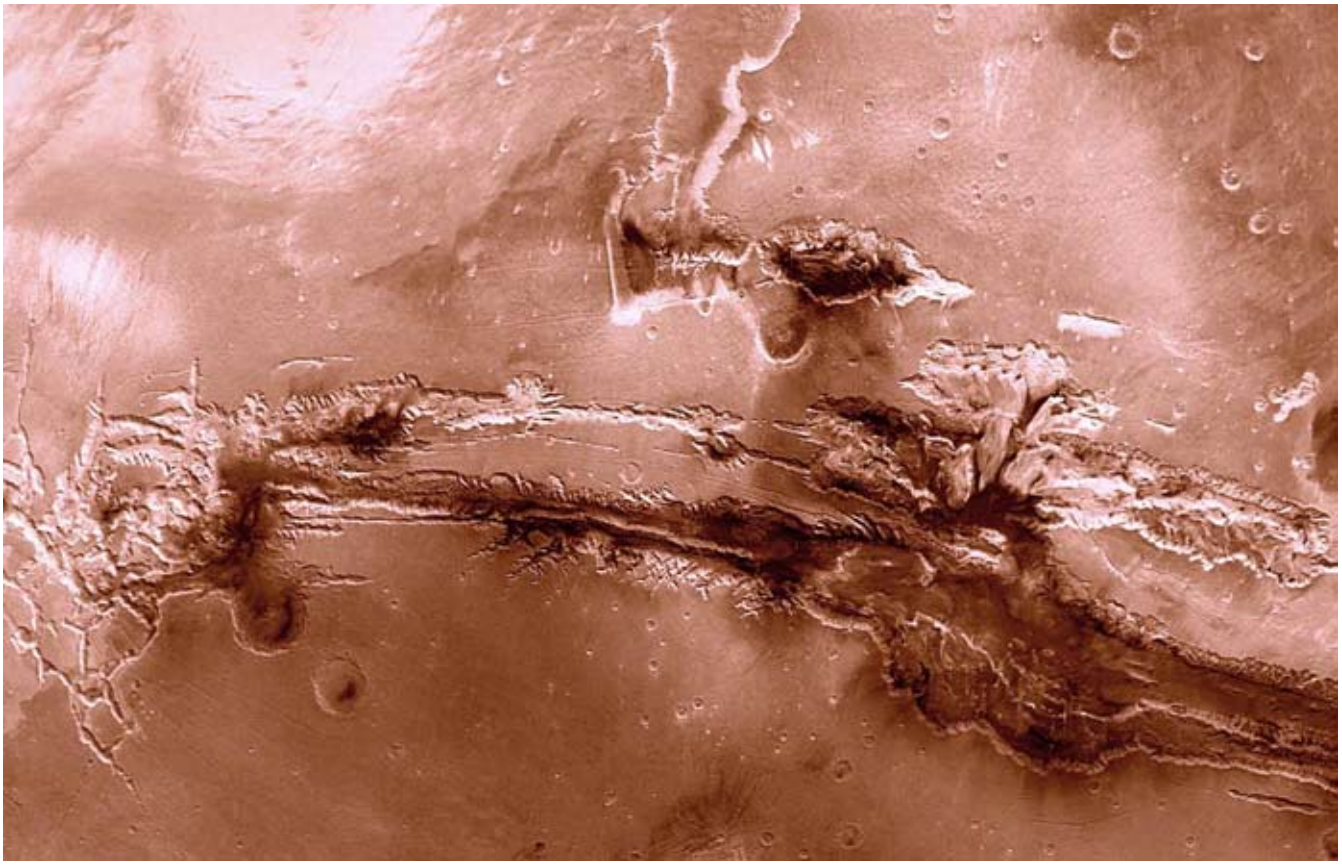
Daedalia Planum



Parana Vallis



Tempe Fossae



Valles Marineris

Select a Landing Site Data Sheet

What is the site name?

Rate this site using: 0= Poor, 1=OK, 2=Good, 3=Excellent.

1. Safe Landing is Poor (0), OK (1), Good (2), or Excellent (3)?

2. Many geologic features? Poor (0), OK (1), Good (2), or Excellent (3)?

3. Special Advantages such as a good place for a colony site, mineral, life, water, active volcanism or a specific geologic feature that you want to see. Poor (0), OK (1), Good (2), or Excellent (3)?

Where Should We Land

What is the site name?

Rate this site using: 0= Poor, 1=OK, 2=Good, 3=Excellent.

1. Safe Landing is Poor (0), OK (1), Good (2), or Excellent (3)?

2. Many geologic features? Poor (0), OK (1), Good (2), or Excellent (3)?

3. Special Advantages such as a good place for a colony site, mineral, life, water, active volcanism or a specific geologic feature that you want to see. Poor (0), OK (1), Good (2), or Excellent (3)?

Name(s) _____

_____

Date _____

A1318

Select a Landing Site Data Sheet

Site Name _____ Rate this site:	Poor (0)	OK (1)	Good (2)	Excellent (3)
Safe landing?				
Many geologic features?				
Special advantage?*				

*Such as a good place for a colony site, minerals, life, water, active volcanism, or a specific geologic feature that you want to see

Where Should We Land?

Site Name _____ Rate this site:	Poor (0)	OK (1)	Good (2)	Excellent (3)
Safe landing?				
Many geologic features?				
Special advantage?*				

*Such as a good place for a colony site, minerals, life, water, active volcanism, or a specific geologic feature that you want to see

Congratulations!

You have been selected to be a member of the Mars Mission planning team.

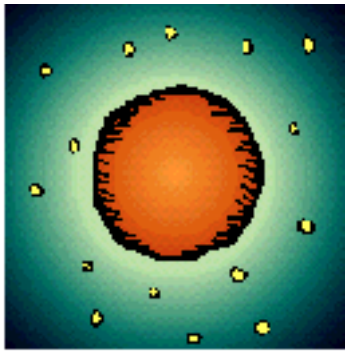
You will decide what type of mission will go to Mars and where it will go on Mars.

The name of your mission is: (fill in name).

You will go to this target on Mars: (fill in name).

To solve this scientific problem. (describe problem)

CONGRATULATIONS!



You have been selected to be a member of the Mars Mission planning team.

You will decide what type of mission will go to Mars and where it will go on Mars.

The name of your mission is: _____

You will go to this target on Mars: _____

To solve this scientific problem: _____

_____

_____