Background Information on the Images in the Image Set

Image 1

This image shows Mars as if you were viewing it from 2,500 kilometers above the surface. It is a mosaic of 102 images taken by Viking I in 1976. This view shows some large impact craters, volcanoes, and Valles Marineris, a huge 4,800-kilometer canyon (across the middle of the photograph). The volcanoes are the three round spots on the left. Each one is 25 kilometers tall and about 350 kilometers in diameter. In this view, the two Martian polar caps are not apparent.

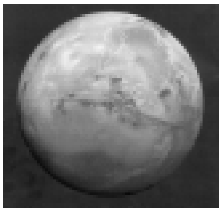

Image 1. Mars hemisphere.

Sample Questions

- What is the feature across the middle?
- What do you think the circles on the left side are?

Image 2

From 18,000 kilometers away and at an orbital height of about 1,500 kilometers, Viking I took this image of the sky above the *Argyre Planitia* (that is, the Argyre Plain). Of special interest are the light-colored bands above the horizon. Dust from a dust storm creates a haze in the atmosphere 25–30 kilometers above the planet's surface. This view emphasizes the shallowness of the Martian atmosphere. (47S, 22W, Viking Orbiter Image 34A13)

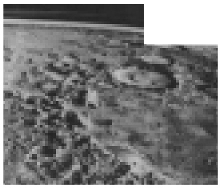

Image 2. View of the thin Martian atmosphere.

Sample Questions

- What is the line on the horizon above the Martian surface?
- How high above the surface is it?
- What causes it to be visible?

Image 3

The surface of Mars has volcanoes, none of which are active. These two shield volcanoes formed as low-viscosity basaltic lava flowed from a central vent. The larger one is 6 kilometers tall, 90 by 130 kilometers in diameter, with a slope of 7 degrees. The smaller one is 3.5 kilometers tall, 60 kilometers in diameter, with a slope of 5 degrees. They are among the steepest volcanoes on Mars. On both volcanoes, note the lava channels and the impact craters. The long, straight fractures on the left formed when the Martian surface in this region bulged upward. (25N, 95W, Viking Orbiter Photomosaic 211-5593)

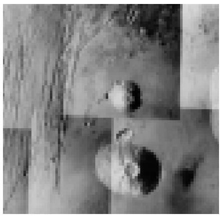

Image 3. Martian volcanoes and fault lines.

Sample Questions

- Which came first, the volcano or the impact craters? How can you tell?
- What might have caused the channels on the side of the volcanoes?
- What are the lines in this image? What might have caused them?

Image 4

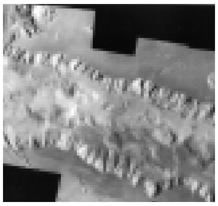

Image 4. A section of the Candor Chasm of Valles Marineris.

Mars has many canyons, and your students can learn more about them in other modules in the series. This image shows a 100-kilometer-wide by 8-kilometer-deep section of the Candor Chasm of Valles Marineris. Valles Marineris is a huge rift valley roughly as long as the United States. Numerous landslides have eroded its edges and widened it. (25N, 95W, Viking Orbiter Frame P40381)

Sample Questions

- What do you think caused the valley?
- What do you think shaped the cliffs on the edges of the canyon?
- How did this canyon get so wide?

Image 5

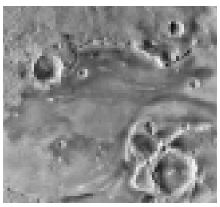

Image 5. Landforms at the mouth of the Kasei Vallis.

This image shows a rich diversity of geological processes. There are fractured, ridged plains (top center), craters as big as 100 kilometers (several have been severely degraded), lobed ejecta blankets, an enormous channel, and wind streaks (going in the opposite direction of the former water flow). (27N, 58W, courtesy of Arizona State University's Planetary Geology Group)

Sample Questions

- Which came first, the fractures or the large crater in the center left?
- Which came first, the crater in the bottom center or the channel?
- Which direction did the fluid flow? Is any fluid apparent now?
- What caused the “tails” behind the small craters in the channel?
- What sequence of events and processes makes most sense in explaining all these features?

Image 6

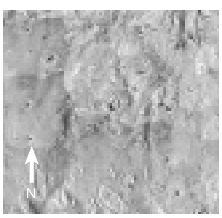

Image 6. Closeup view of Pathfinder's landing site at the mouth of the Ares Vallis.

This image shows the area around Pathfinder's landing site (19.35N, 33.55W). Although there is currently no liquid water on Mars, the landforms strongly suggest that water flowed in an earlier stage of Mars' history. Note the landforms sculpted by flowing water (suggesting that large-scale floods swept this region), a smooth outwash plain (good for a safe landing and full of sediments from upstream), and impact craters with mud-flow-like ejecta blankets (suggesting water or ice-rich surface layers, an idea consistent with flooding). (USGS Photomosaic I-1345)

Sample Questions

- What do you notice about this region?
- How might the teardrop-shaped landforms have formed?
- What might make this region a desirable landing site?
- Do you see anything that might make this an interesting area to explore?

Image 7

This image highlights many of the region's interesting features. Channels descend 2 to 3 kilometers from a plateau that surrounds most of the low-lying Chryse Planitia. Many channels emanate from rough-looking depressions. These are *chaotic terrain,* a unique Martian feature that formed when large areas of permafrost melted, causing the surface to collapse. The numerous areas of chaotic terrain and the many channels suggest that flowing water was a regional phenomenon. As water flowed downhill, it crossed many different types of terrain and carried sediments from the highlands. The possibility of finding sediments from many rock types at the mouth of this channel made Pathfinder's landing site exceptionally valuable to scientists wanting to learn more about the geology and hydrology of Mars. While there are many lobed ejecta blankets in the Chryse Planitia, there are none in the highlands. Because lobed ejecta blankets occur only in water or ice-rich areas, the highlands must have been drier than the plain at the times of impact. Also, the highlands are heavily cratered, while the Chryse Planitia is relatively free of craters. Our solar system experienced a period of heavy bombardment by asteroids 3 billion years ago. This bombardment created most of the craters on Mars, so the floods that obliterated the Chryse Planitia's craters must have occurred after that time. (Detail from USGS Map I-1448)

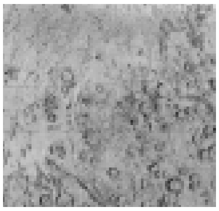

Image 7. Regional map of the Ares Vallis.

Sample Questions

- How big is this area?
- What is the general topography of this region? Which direction is uphill?
- How much water flowed in this region, a little or a lot?
- From where might the water that flowed in these channels have come?
- Why is the area at the end of the channel so smooth? (*It is a floodplain covered with sediment.*)
- What do you think the Chryse Planitia looked like when water flowed in the channels?
- Describe the distribution of craters in this region.
- What might explain this pattern of distribution?
- What are some differences between the craters on the plain and in the highlands?
- What might explain the differences between the craters in these two areas?

Image 8

This image was made on Pathfinder's fourth day. "Twin Peaks," the two hills about 1 kilometer away from the landing site, are of great interest to scientists. Sections of the hills look stratified, and white areas on the left hill (nicknamed the "Ski Run") may represent a high-water mark from one of the floods that swept this area. The jumbled boulders in the foreground probably were carried from upper portions of the Ares Vallis by ice or water. Sojourner used its Alpha Proton X-ray Spectrometer to determine the mineral composition of rocks and soil around the landing site.

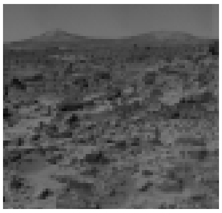

Image 8. The view from Pathfinder toward Twin Peaks.

Sample Questions

- Does this look like any place on Earth?
- Why did the landing site look so smooth when it is really full of boulders?
- What are some ways a plain such as this can become littered with rocks?

Image 9

Image 9. Valles Marineris and the surrounding region.

This map shows some of Mars' most prominent features. Olympus Mons, the left-most volcano, is the largest volcano in the solar system at about 27 kilometers high and more than 600 kilometers across at the base. Valles Marineris is the largest canyon in the solar system. It is a system of rift valleys that together stretch more than 5,000 kilometers in length. A 30 million square kilometer section of the Martian surface bulges nearly 11 kilometers. This bulge is centered on the western end of Valles Marineris and may have formed when magma rose from deep within the planet, causing the lithosphere to dome upward and fracture. One can see many fractures radiating radially from the bulge. The many volcanoes in this region attest to the existence of an active magma chamber at one time. The smooth-looking surface around the volcanoes was caused when lava flows covered the surface that scientists believe was once as heavily cratered as the surface in the bottom right of the map. On the eastern end of Vallis Marineris, channels flow from areas of chaotic terrain in the highlands onto the Chryse Planitia. Both the 1976 Viking I and the 1998 Pathfinder missions landed in the Chryse Planitia. (USGS Map I-1618)

Image 10

Image 10. The Ophir Chasma.

The Ophir Chasma is one of the northern-most canyons of Valles Marineris. It is approximately 125 kilometers wide and 325 kilometers long, and the walls are about 5 kilometers tall. The plateau at the top of the canyon is probably a thick deposit of lava, and the resistant rock layers form steep cliffs at the upper edges of the canyon. These cliffs are vulnerable to landslides, and, indeed, numerous landslides have widened the canyon. (USGS Photomosaic I-1592)

Sample Questions

- What processes have affected this canyon?
- Why might the plateau be so smooth?

Image 11

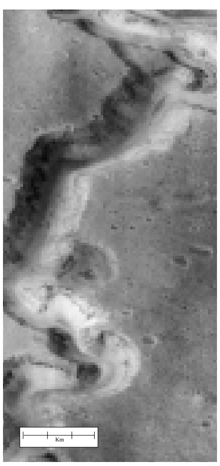

Image 11. The Nanedi Vallis.

The Mars Global Surveyor took this image of the Nanedi Vallis, one of the Martian valley systems cutting through cratered plains in the Xanthe Terra region of Mars. The picture covers an area 9.8 by 18.5 kilometers, and features as small as 12 meters can be seen. The canyon is about 2.5 kilometers wide. You can see rocky outcrops along the upper canyon walls and weathered debris on the lower canyon slopes and along the canyon floor. The origin of this canyon is enigmatic: some features, such as terraces within the canyon (near the top of the frame) and the small 200-meter-wide channel (also near the top of the frame) suggest continual fluid flow and downcutting. Other features, such as the lack of a contributing pattern of smaller channels on the surface surrounding the canyon, box-headed tributaries, and the size and tightness of the apparent meanders, suggest formation by collapse. It is likely that both continual flow and collapse have been responsible for the canyon as it now appears. Further observations, especially in areas west of the present image, will be used to help separate the relative effects of these and other potential formation and modification processes. (These notes are courtesy of Malin Space Science Systems. Image available on NASA's Planetary Photojournal, *http://photojournal.jpl.nasa.gov/cgi-bin/PIA GenCatalogPage.pl? PIA01170)*

Sample Questions

- What processes have affected this canyon?
- What evidence is there for the idea that water flowed here?
- What evidence is there against the idea that water flowed here?

Image 12

The Red River of Louisiana is a tributary of the Mississippi River. It meanders over a broad floodplain bordered by higher, more rugged uplands. Notice that the river undercuts the valley walls just north of Grand Ecore (near the upper right corner of the legend). Undercutting happens because inertia carries most of the water to the outside of the curve. Conversely, sand bars (shown by dotted lines) form on the inside of river curves because the slowness of the current on the inside of a curve permits the deposition of sand by the river. The several oxbow lakes formed when the Red River cut through the land, originally creating the meander, thus isolating the former river bend. The Nanedi Vallis on Mars (Image 11) is quite similar to the Red River in that it, too, has a narrow river carving a wide valley, meanders, two oxbow lakes in the early stages of formation, undercut rocky ledges, and sandbars on the inside of the bends. Such interplanetary comparisons support the view that, at one time, Mars had a climate that could support the long-term flow of water. (Detail of USGS Map 3200N9315W/15)

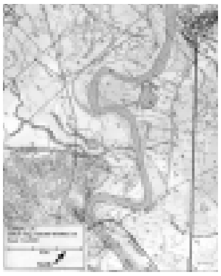

Image 12. Oxbows and meanders of the Red River in Campti, Louisiana.

Sample Questions

- How are the two banks different as the river goes around a bend?
- How did the oxbow lakes form?
- How does the Red River compare with the Nanedi canyon?

Image 13

This image exhibits many of the same features seen in Image 12. However, these rivers wind through a mountainous terrain and change direction each time they meet a significant obstacle, such as a mountain side. Again, students can see how a river undercuts the banks on the outside of a curve and deposits sediments on the inside of the curve. They can also speculate on the fate of the hills separating one meander from the next. At some point, the river will erode these hills and cut through them to create islands. Ultimately, oxbows will form. It has taken eons for these rivers to develop their meanders. They probably started as straight runoff channels. As they eroded the land, they took on the meandering shape characteristic of mature rivers. The shapes of river beds and river valleys give scientists an idea of how long water has flowed over an area. Because the Nanedi Vallis meanders and is quite deep, water must have flowed for a long time. (Detail of USGS Map 3849N7827W/15)

Image 13. Meanders of the North and South Branches of the Shenandoah River in Strasburg, Virginia.

Sample Questions

- How do the valleys carved by the Shenandoah and Red Rivers compare to the Nanedi Vallis?
- How long might it take for a river to form a valley of this size?
- On which side of each sharp turn is the bank steeper?
- What factors might influence how quickly a valley forms?

Images 14 and 15

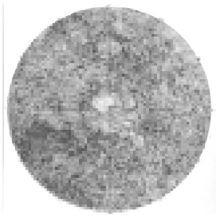

Image 14. The Martian South Pole.

Because of Mars's elliptical orbit, the southern winter is colder than the northern winter, and the south pole is composed primarily of solid carbon dioxide (that is, dry ice). By contrast, the north pole is primarily water ice and is considered a reservoir of considerable amounts of Martian water. Scientists know this because they see the south pole get smaller during its summer at temperatures far below the melting point of water. The north pole remains a constant size, even though its temperature is above that needed for dry ice to sublimate. The spiraling is thought to be caused by differential melting—slopes facing the Sun melt and retreat, while ice and dry ice accumulate on the slopes facing away from the Sun. (USGS Map I-961)

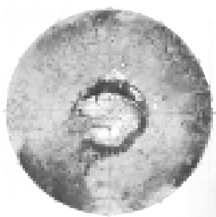

Image 15. The Martian North Pole.

Sample Questions

- How might one tell whether the poles are covered with water ice or dry ice?
- What might cause the spiraling shape of the poles?