AT A GLANCE

Overview

This activity introduces students to one of the main geologic reasons why the mouth of Ares Vallis is such a desirable landing site. By examining sand samples from different locations, students realize that sediments can provide information about where they originated and how they were deposited. By looking at the abundance of various minerals and the condition of the grains, students formulate a reasonable history for each sand sample. They then locate Ares Vallis on a map and speculate about what *Pathfinder* might find in the sediments there.

Content Goals

- Sand grains contain clues about their origin and history.
- A sand sample reflects the geology of its watershed or region.
- One of *Pathfinder's* mission objectives is to gather evidence that will enable scientists to better understand the composition of the Martian crust and the planet's early geologic history.
- Ares Vallis was selected as the landing site because it satisfies the geologic and engineering criteria for the mission.
- The Thermal Emission Spectrometer on the *Mars Global Surveyor* and the APXS mounted on the micro-rover will enable scientists to determine the abundance of major chemical elements in the rocks and soil near the lander.

Skill Goals

- *Observe* differences between various sand samples and among individual sand grains.
- *Interpret* the clues contained in a sample of sand.
- *Estimate* the size of the area *Pathfinder* will be able to sample from within the landing ellipse.
- *Explain* the appeal of Ares Vallis as a landing site in terms of its geological potential.

Possible Misconceptions

- Sand rises to the surface from the ground below it.
  Ask: What is sand? Where does it come from?
- Each rock (and all sand) is made from one kind of material.
  Ask: Is a rock (or sand) made from one or many different materials? How do you know?
- Rocks and sand grains have always had the shape we see today.
  Ask: How did this rock get this shape?
- The material that covers the surface of Mars is all the same.
  Ask: Is the land on Earth all covered by the same material?

Materials

Sand from several locations, magnet, tape, magnifying glass, marker, Image set.

Preparation

- Provide students background in interpreting sand grains.
- Gather sand samples from a variety of locations.

Time

1-2 class periods

The Pathfinder landing site is roughly 850 km southeast of where Viking I, the first Mars lander, landed on July 20, 1976.

The use of the term SAND (particle size 1/16-2.0 mm) may lead students to expect to find sand on Mars. Surprisingly, no sand has been found on Mars. The tremendous winds seem to have pulverized the "soil" into a fine silt (particle size 1/256-1/16 mm) texture. However, the process of a channel delivering sediments from a large area to its mouth still pertains.

According to Scientific American Magazine ("Sands of the World," August, 1996), it takes approximately ten thousand years for a medium-sized river to move a sand particle one mile downstream.

Fig. 6.1
Pathfinder Landing Site at the Mouth of Ares Vallis. Image set image #6.

Pathfinder landed on Mars on July 4, 1997, within the 100 km x 200 km ellipse at the mouth of Ares Vallis (Fig. 6.1). To be selected, this site had to fulfill some very particular engineering and geologic criteria.

The main engineering challenge was landing the space probe safely. *Pathfinder* used a parachute to slow its descent (Fig. 6.2). However, Mars has an atmosphere one-hundredth that of Earth's, so slowing a spacecraft with a parachute is more challenging on Mars. One way to compensate for the less dense atmosphere was to select a landing site at one of the lowest places on Mars, and this gave *Pathfinder* more time to descend through the densest part of the atmosphere near the planet's surface. The landing site at the mouth of the Ares Vallis is 1.5 km (1 mi) below *datum*, the Martian equivalent of Earth's sea level.

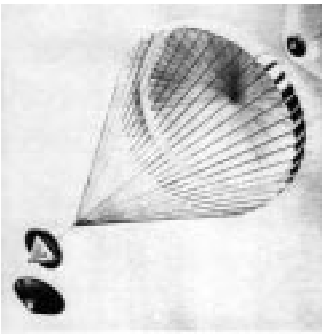


Fig. 6.2
Parachutes slowed Pathfinder's descent.

Another engineering reason to choose Ares Vallis is that it lies within 15 degrees of the equator. Any site within 15 degrees north or south of the equator receives significantly more sunlight than areas outside this band. Since *Pathfinder* depends on electricity from its solar panels, the best landing sites are within these latitudes (Fig. 6.3).

Fig. 6.3
The Mars Pathfinder lander with its solar panels deployed.

An important geologic reason for selecting the Ares Vallis landing site is the fact that it is at the mouth of an outflow channel that probably has a rich assortment of sediments. Over its approximate 1,800 km (1,125 mile) length, Ares Vallis passes through a variety of rock types representing different periods in the geologic history of Mars. Rocks are composed of mineral grains. As rocks weather, mineral grains separate from each other and become mixed in with soil and sediments such as sand (Fig. 6.4). Since channels typically transport sediments from along their course, Ares Vallis is thought to have carried rocks and sediments from distant reaches, including the ancient highland terrain of the southern hemisphere. Sampling rocks and sediments at the mouth of Ares Vallis increases the likelihood that scientists will be able to learn about the Martian geologic history represented by these rocks and minerals.

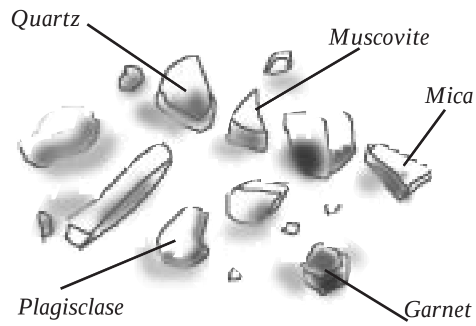


Fig. 6.4
Sand is a mixture of rock fragments.

One of the instruments carried on the rover is the Alpha Proton X-ray Spectrometer (APXS), which bombards rock and soil samples with alpha particles (Fig. 6.5). Detectors determine the energy of the alpha particles, protons and x-rays emitted off the surface being bombarded. Elements such as carbon, oxygen, magnesium, aluminum, silicon, calcium, potassium, iron and nickel can be identified, and this will allow for the investigation of rock and soil composition.

Fig. 6.5
Sojourner sampling a rock with the APXS.

Activity 6 demonstrates the way sand can be used as a source of information. It is said that each handful of sand has a story to tell and contains many clues that help unravel that story. For example, by looking at the shapes and sizes of individual sand grains, one can determine their histories. For instance, newly fragmented mineral grains have crisp, angular edges while old mineral grains are rounded and smoothed (Fig. 6.6). Furthermore, small, light particles travel more easily than large, heavy ones, so beaches and deltas with fine sediments indicate calmer waters.

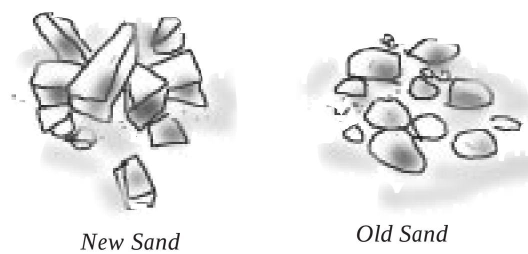


Fig. 6.6
A comparison of old and new mineral fragments.

Since each stream or river travels a unique course over a unique set of geological features, it picks up a unique set of rock fragments. By comparing sediments from different rivers or from different places along the same river, one can determine the types of rock over which a river has flowed. Looking at sand along a river can be an effective way of sampling the types of rock from a large geographic area (Fig. 6.7).

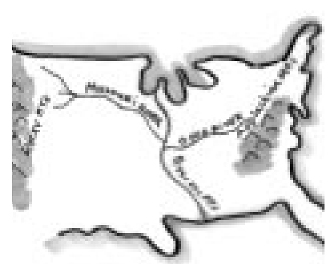


Fig. 6.7
Mississippi River drainage.

PROCEDURE

1. Introduce students to interpreting sand grains. Even without background, students can distinguish between sand from different locations based just on visual inspection. However, they may not be able to understand what grain size, shape and condition imply about a grain's history. Find objects such as bricks, wooden blocks, pasta, coins, marbles, or books in different states of repair. Ask students what they can infer about the histories of these objects based just on what they observe.
   Broken bricks have been jostled or crushed. Unblemished pasta just came out of the bag. Tattered, torn books have traveled in a backpack for a long time. A cookie could end up as a collection of crumbs.

2. Place each sand sample in a jar. To get a thin layer of sand from each jar, have students press a strip of tape onto the top of each sample. Have them label the strip of tape with the sample name or number.

3. Have students examine the magnet in each sample's supply jar to see if there are any magnetic particles.
   Certain sands contain iron-bearing minerals. One can see if there are iron particles in your samples by passing a magnet through the sample a few times.

4. Have students view the taped sample with a magnifying glass and count the number of different types of mineral fragments stuck to the tape. If they know how to identify rock and mineral types, have them make a list of what they see (Fig. 6.8).

5. Have them repeat Steps 2-4 with the remaining sand samples.

6. Have students describe some major differences between the sand samples.

7. Based on their observations of the sand samples, have them try to describe the river that transported the sand or the conditions at the collection site:

   a) How strong was the current at the collection site?
   Large grains correspond to strong current whereas small grains or silt correspond to gentle current.

   b) Geologically speaking, how varied is the geology over which this river flows?

   c) Can you tell which rock fragments traveled the furthest?
   Sand grains traveling the furthest will be smooth and well rounded. However, some minerals are stronger than others. It is possible to have a weak mineral such as mica look more worn even though it has traveled less far than a stronger mineral such as quartz.

   d) If the answer to Question 2c was yes, can they place the sources of the rock fragments in order from the source furthest upstream to the one closest to the collection site?

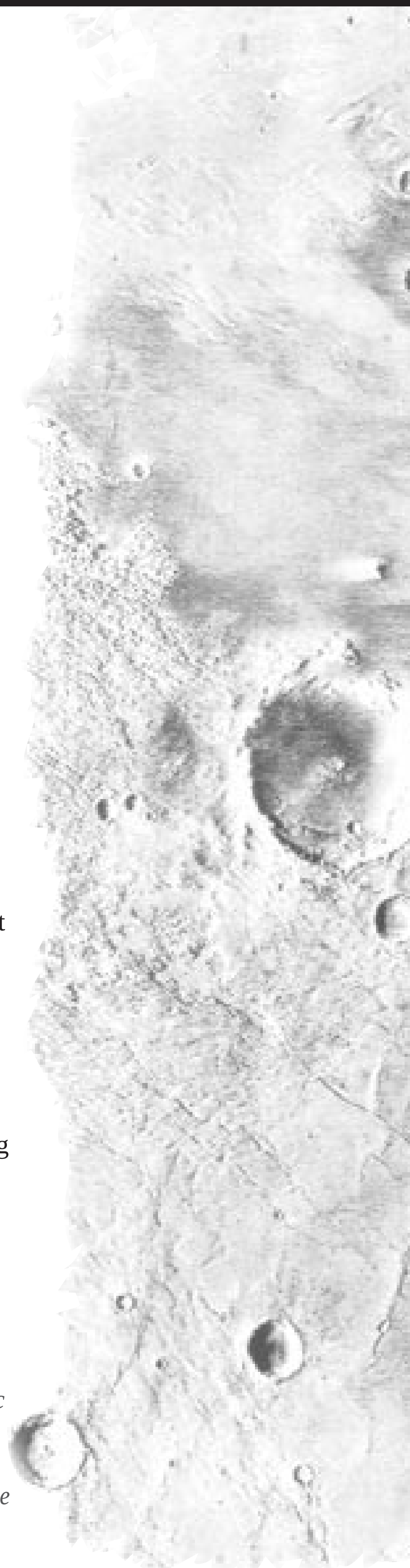
Fig. 6.8
Looking at sand samples on a strip of tape.

APPLYING THE MODEL TO MARS

1. Have students look at the images showing the mouth of Ares Vallis (Fig. 6.9). What would they expect to find on the plain where Ares Vallis joins the Chryse Planitia?

2. Assuming the idea that rivers pick up sediments from the rocks over which they flow is correct, estimate the size of the area *Pathfinder* will be able to sample from within its landing ellipse.
   The area is approximately 1,000,000 km^2 (250,000 mi^2). More important than the size of the area drained by these two channels, however, is the fact that they cross a diverse terrain representing Martian geologic history from at least three epochs (approximately 1.3 billion years) during which Mars was very geologically active.

Fig. 6.9
The Mars Pathfinder landing site at the terminus of Ares Vallis.



Questions

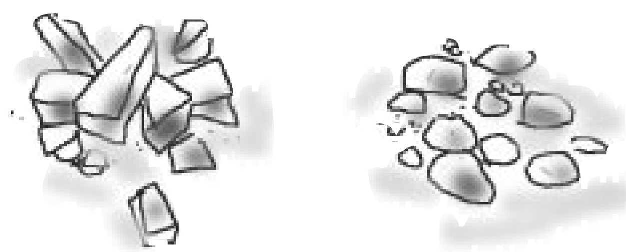
1. To more fully understand the clues contained in the sand samples, what else might be important to know?
   Names of rock and mineral types in the sand, geology of the watershed, the area's climate, the natural history of the river over the last several thousand years, the amount of elevation drop from headwaters to collection site, activities in the watershed affecting sediment load such as cities, logging, mining, grazing, construction, fires, etc.

2. What distribution of sand grain size and condition would you predict to find along an ocean beach? Along a lake beach? Does it change throughout the year?
   Where the surf is rough, sand grains will be large and only a few resistant minerals such as quartz will be present. In protected coves and bars, sand grains will be smaller and there will be a heterogeneous mix of minerals. Winter storms remove finer sediments from beaches.

3. Why is the mouth of Ares Vallis such a desirable landing site?
   Ares Vallis satisfies both the engineering (strong sunlight and low elevation) and geologic criteria for the mission. Activity 6 makes a case for sediment being able to provide information about a planet's history. By landing at a site with diverse sediments from rocks formed at different times, scientists stand to learn a great deal about the composition of the Martian surface and geological history of Mars from this one visit.

TEACHING POINTERS

Sand may be collected from any stream, river, arroyo, or beach. Even if there is only one such water course in your area, taking samples from the inside and outside of meanders, from locations a few miles apart, from the stream channel and stream bank, etc. should give you sufficient variation. Hardware stores sell sand, and it is also available from cement yards and can be borrowed from sandboxes.



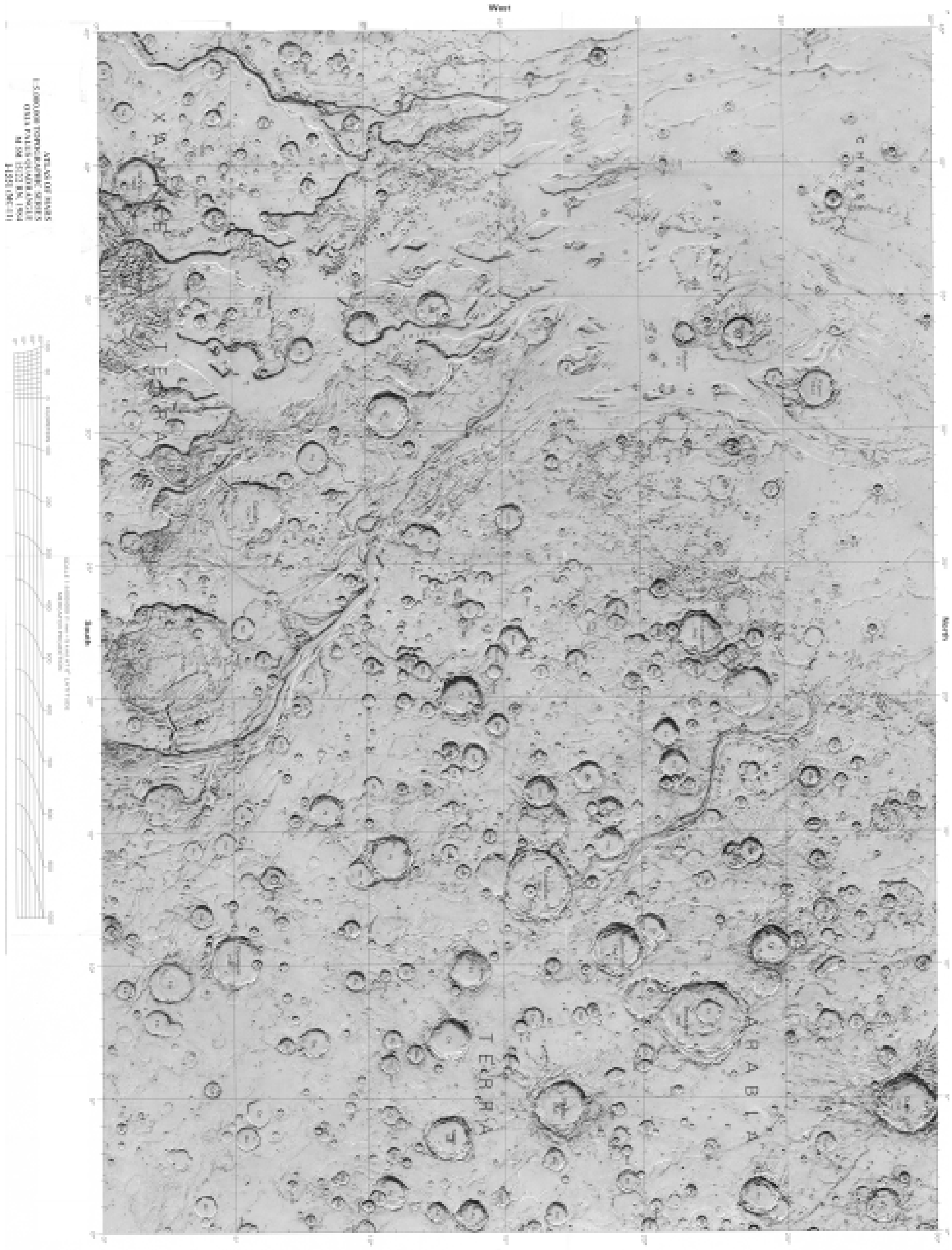


Image 1 **Regional map of the channels descending from the highland plateau to the low-lying Chryse Planitia (*Chryse plain*) 2-3 km (1.25-2 mi) below. This map adjoins Image 2.**

Image 5 Photomosaic showing where the Ares, Tiu, Simud and Shalbatana Valles join the Chryse Planitia. The inset shows the Scablands at the same scale. The scale is on the *south* edge if the image.

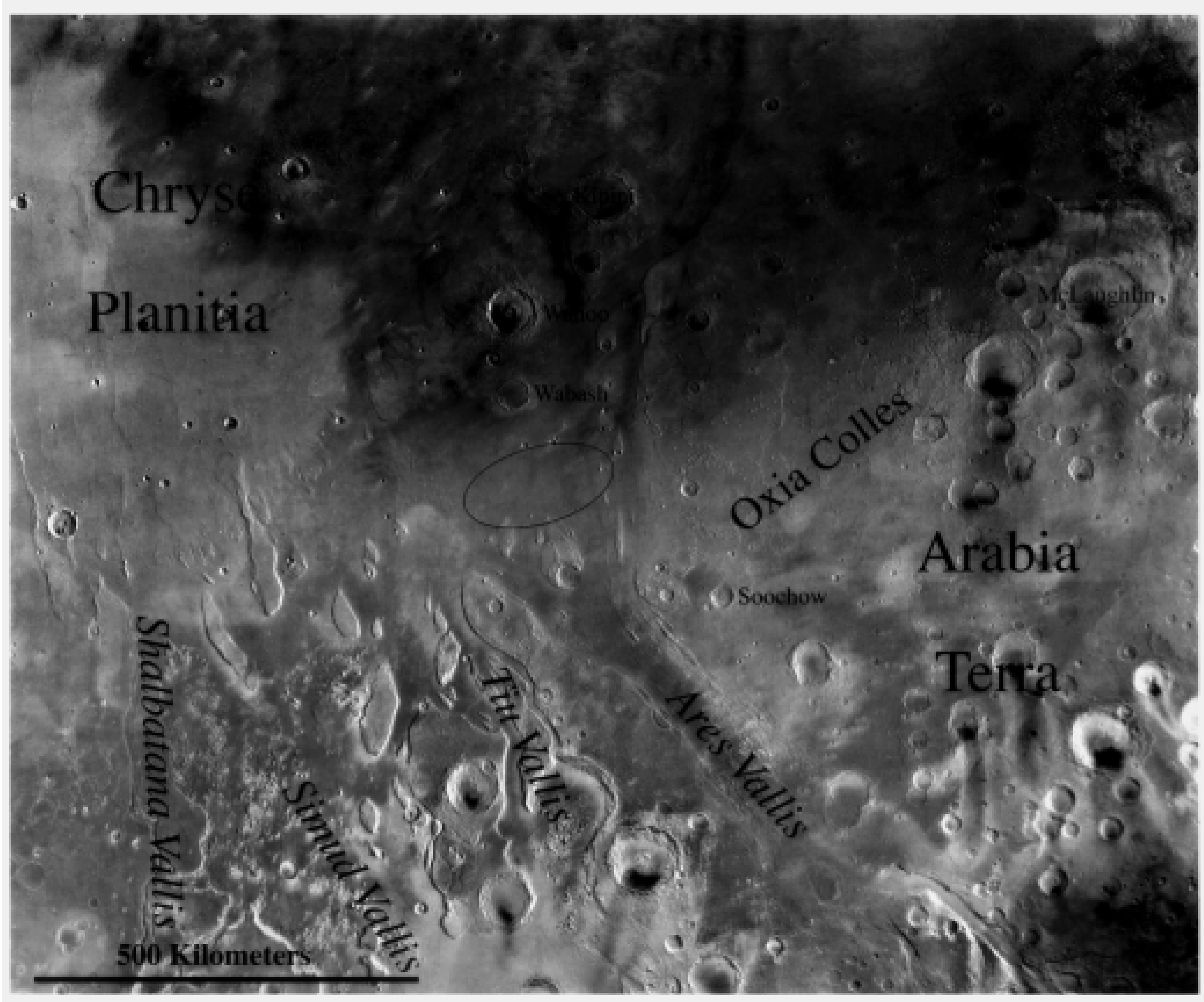


Image 6 Photomosaic showing the region surrounding the 100km x 200 km ellipse (superimposed on the image) that marks where NASA intends to land *Pathfinder*. From which directions might the spacecraft approach the landing?

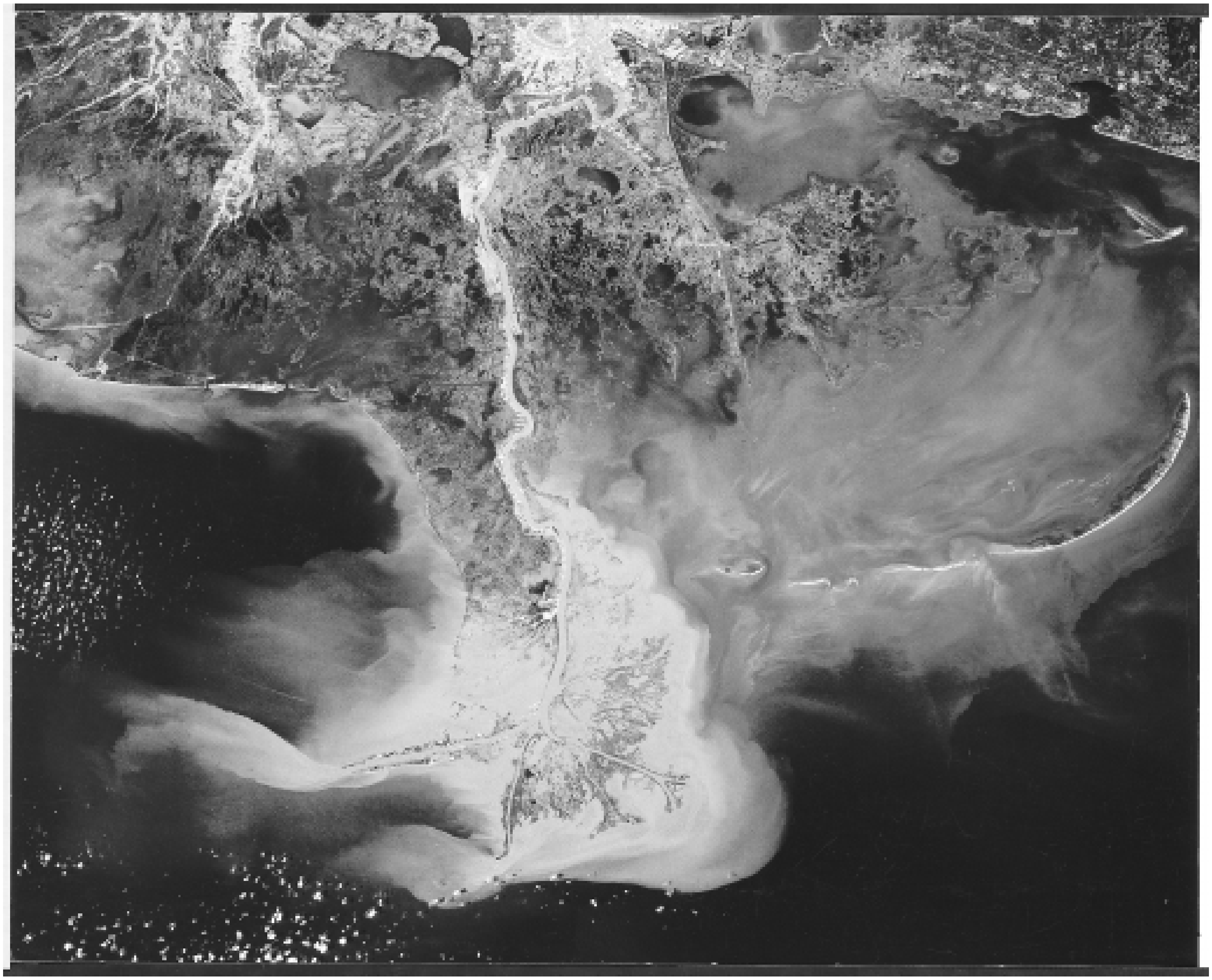


Image 13 **Space Shuttle photograph of the sediment-laden Mississippi River and the delta it is forming in the Gulf of Mexico below New Orleans.**

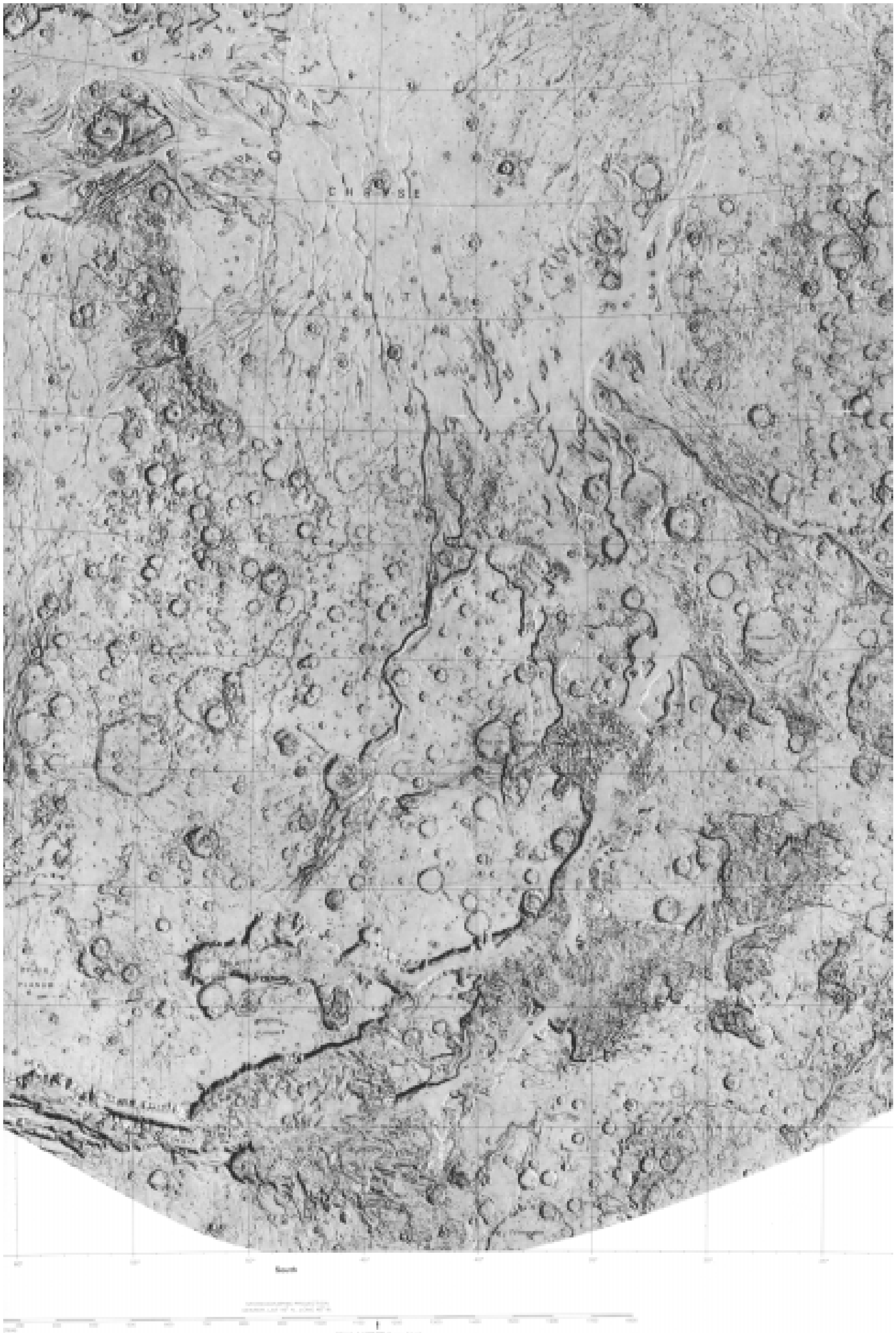


Image 16 Map showing the regions to the south, east and west of the Chryse Planitia. Note the chaotic terrain at the end of Valles Marineris and in the Margaritifer highlands, and the channel systems descending 2-3 km (1.25-2 mi) to the Chryse Planitia.