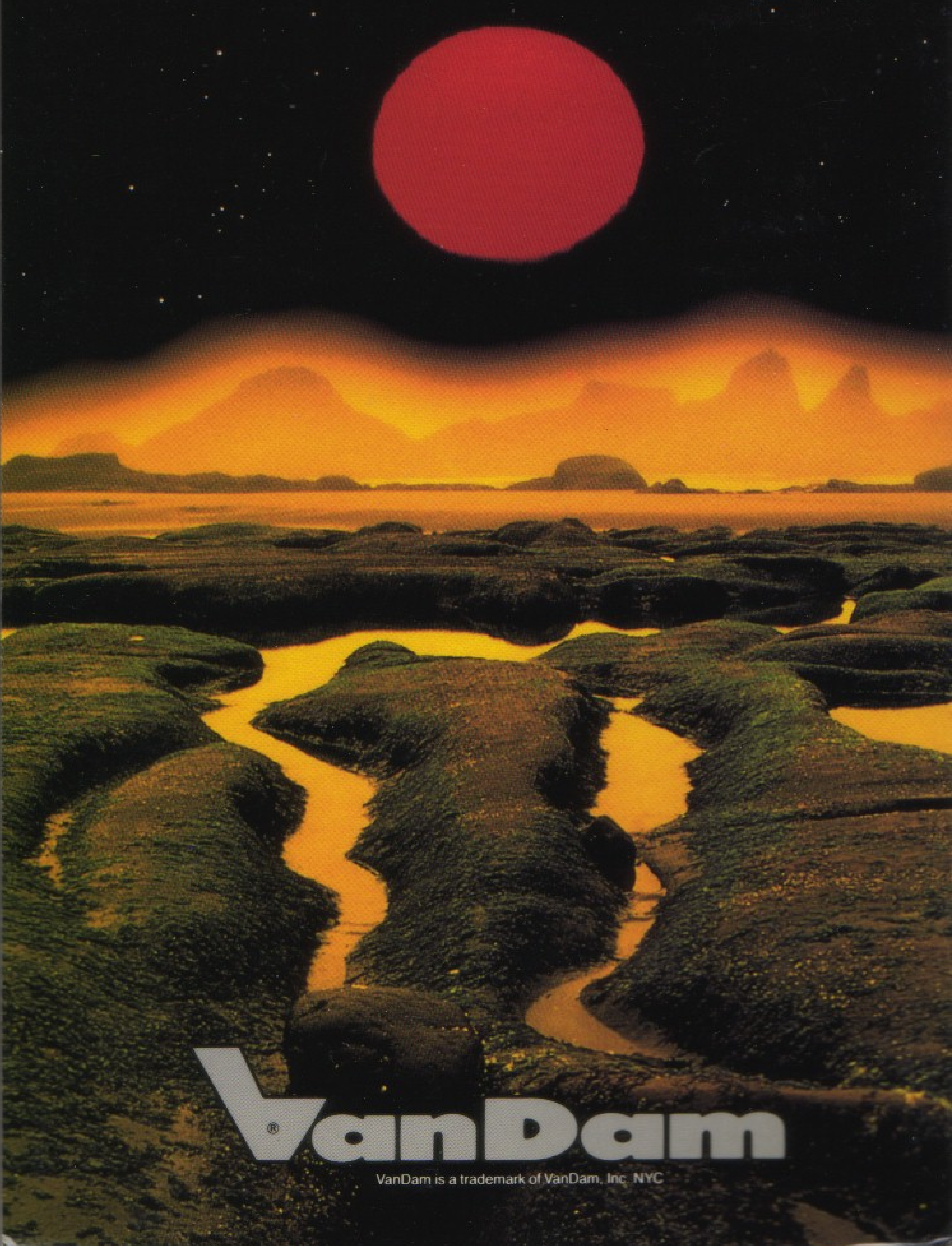
# MARS

# *Space Atlas* UNFOLDS®



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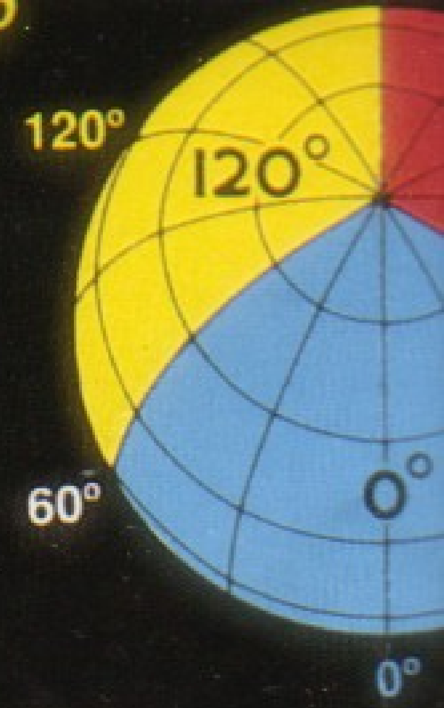
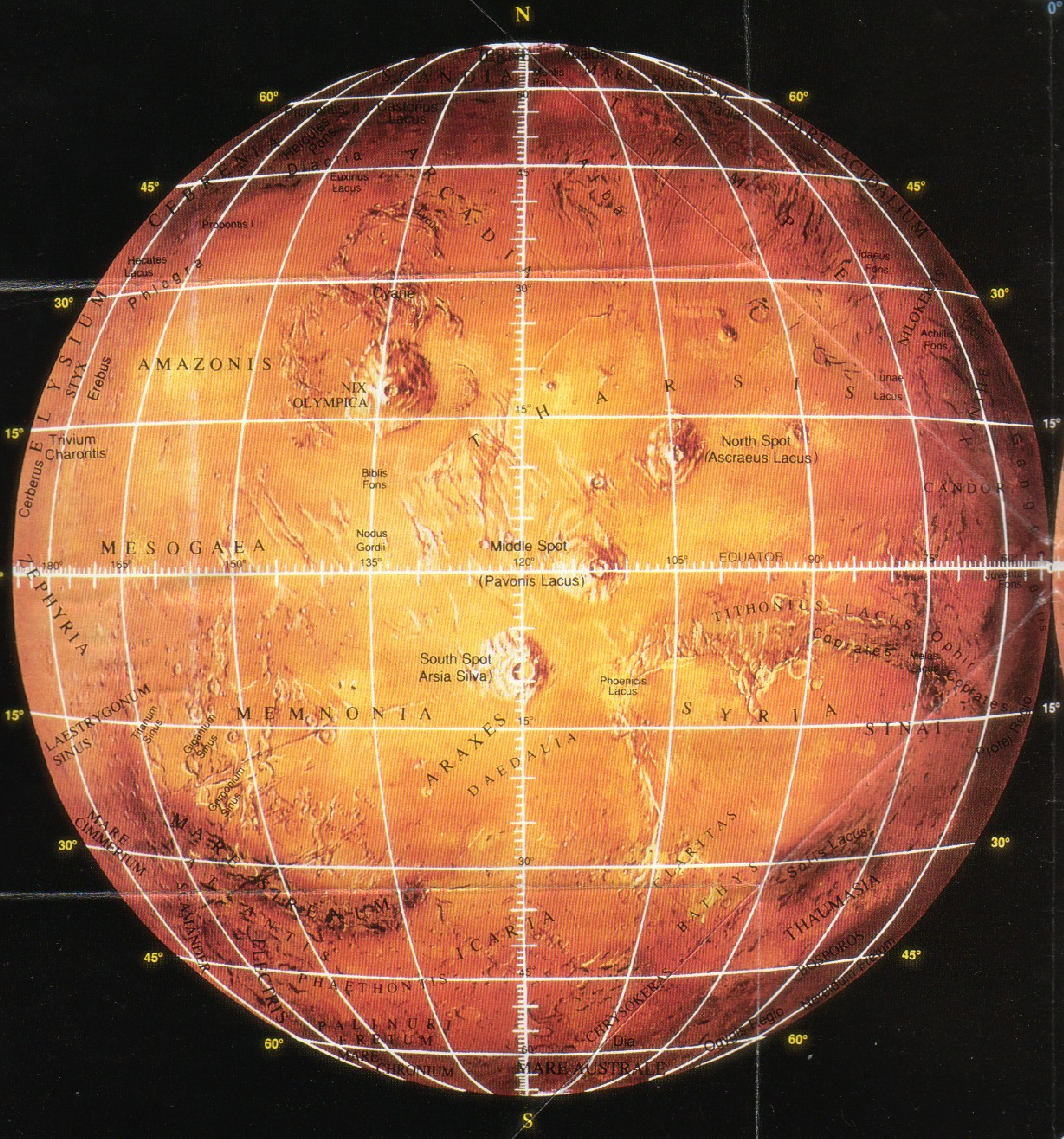
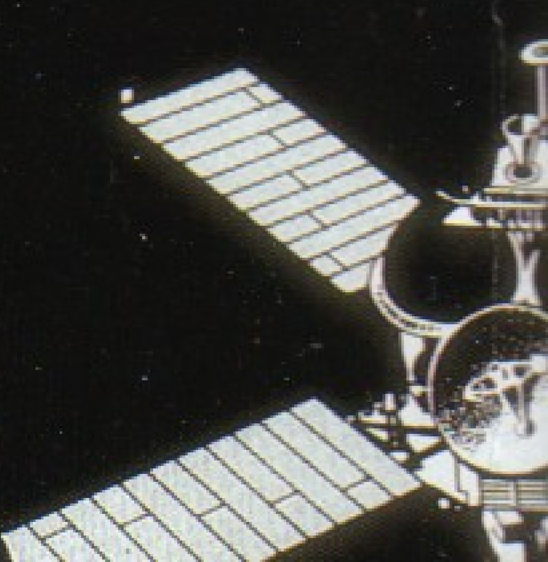
THREE EQUATORIAL AND TWO POLAR VIEWS OF MARS are featured.

Shown below are two views centered on 0°, and 120° longitude. A 240° perspective appears on the second fold-out and completes the trio.

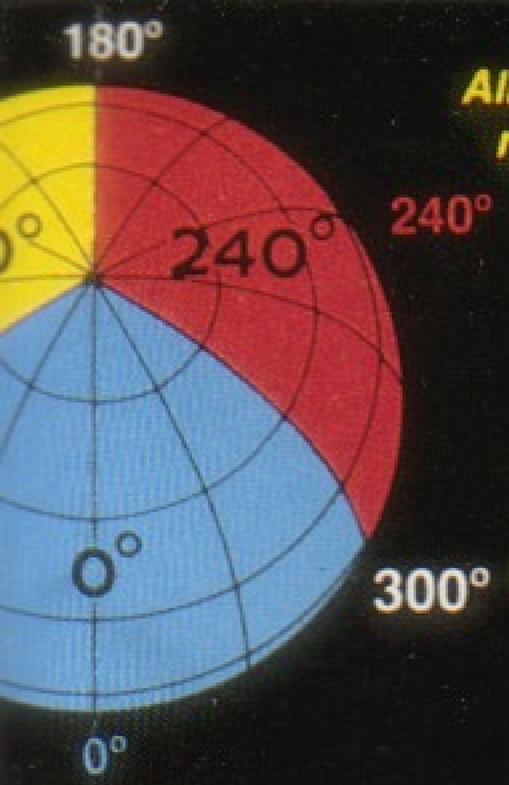



CENTRAL MERIDIAN 120°
Scale: 1:30,200,000

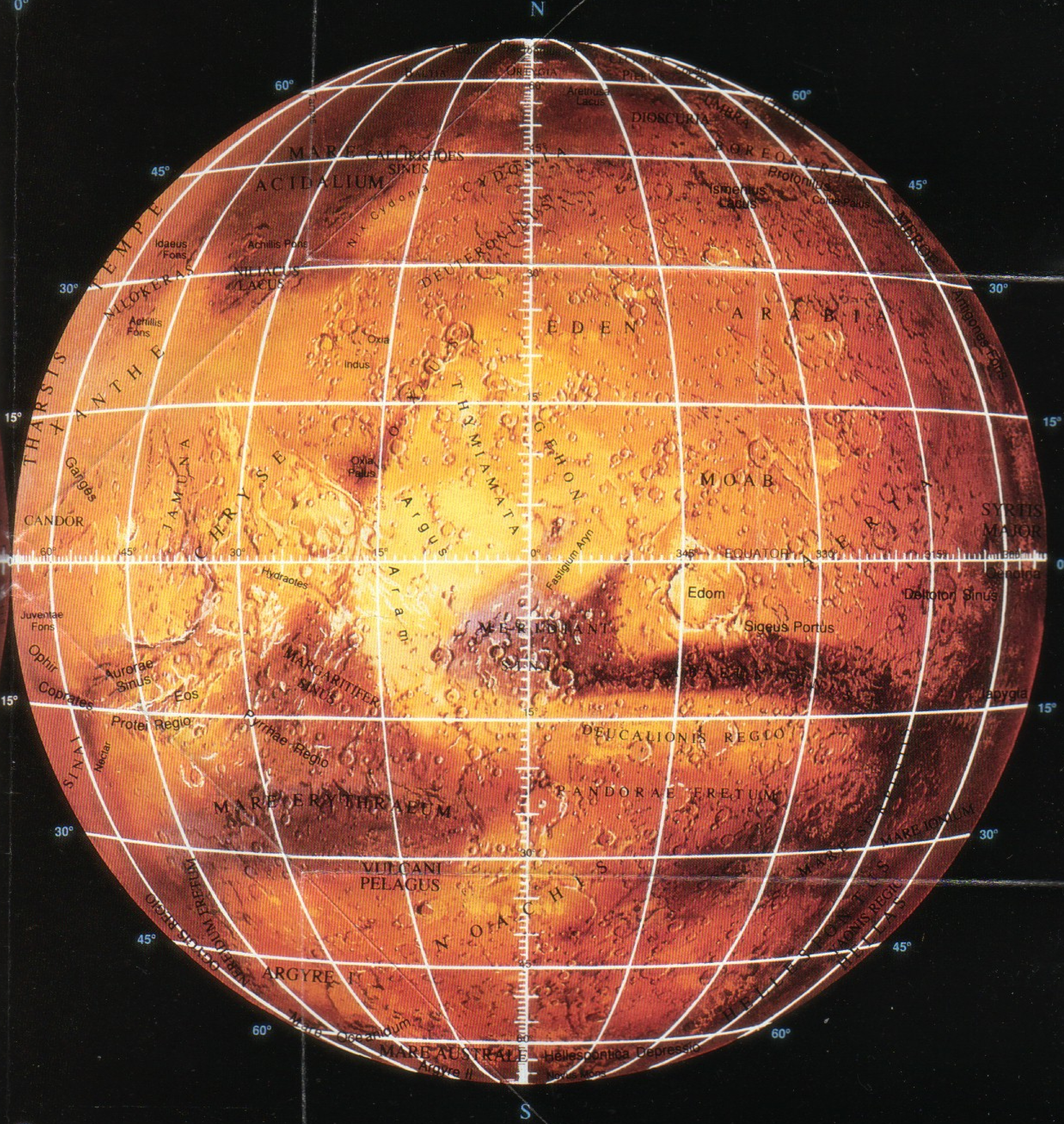


# MARS
## The red planet




*All three equatorial images represent complete hemispheres, at a scale of 1:30,200,000.*

*The two polar areas, on the second fold-out, are presented at a scale of 1:21,800,000 and appear larger than in reality.*




**CENTRAL MERIDIAN 0°**
**Scale: 1:30,200,000**

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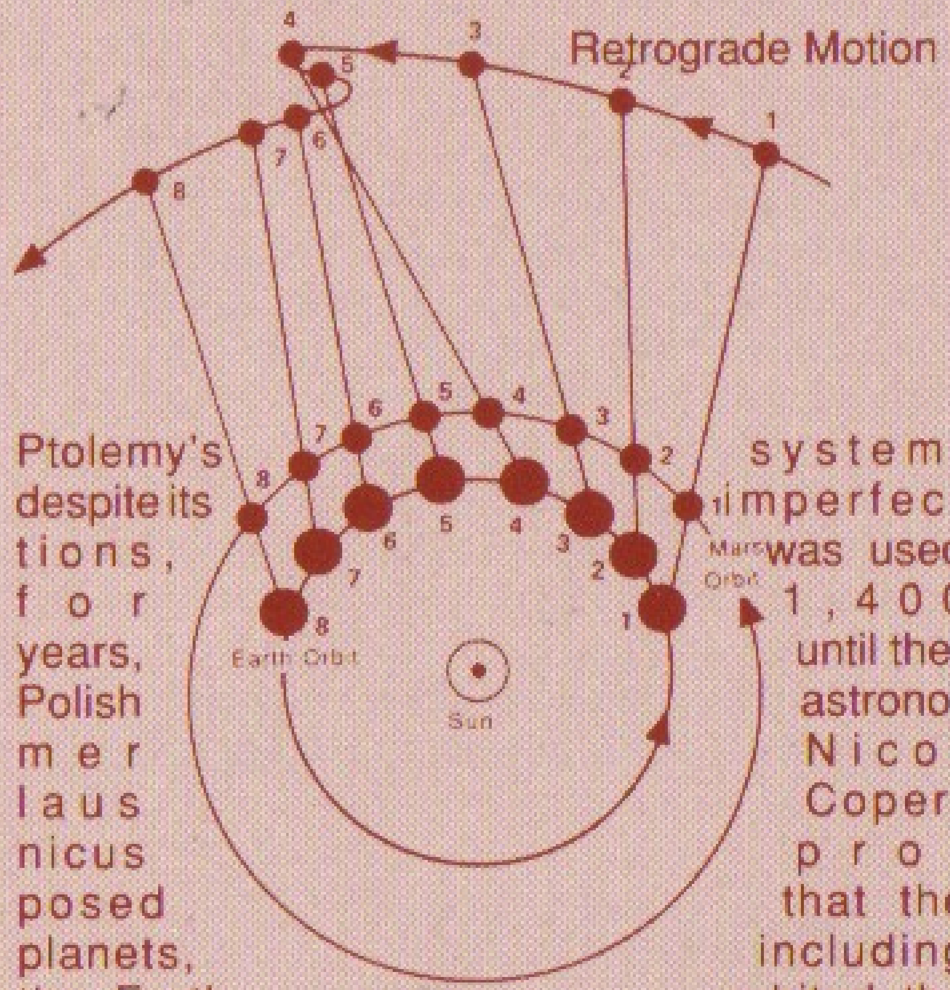
# The Martian chroniclers

Much of the development of science has been driven by humanity's fascination with Mars, which has been carefully observed by shepherds, seafarers, scientists, and storytellers since the dawn of history.

By the time the Egyptian mathematician and astronomer Claudius Ptolemy wrote *The Almagest* in the 2d Century A.D., written records of astronomical observations had been accumulated for nearly 1,000 years. Everyone could see that Mars appeared to reverse course occasionally in its east-west movement across the sky, and this fact frustrated efforts to construct a simple model of the universe.

Several models had been attempted, including one by Aristotle in the 4th Century B.C., on the common assumption that the Earth was the center of the universe — the "geocentric" hypothesis. Other ancient philosophers had worked out non-geocentric theories. But none could explain and predict the movements of celestial objects as well as Ptolemy's.

Ptolemy hypothesized a system of heavenly circles about the Earth, with "equants" and "epicycles" about lesser bodies, wheels within spinning wheels that accounted for most of the known data about the movements of the sun, moon, stars, and planets. It got very complicated and ungainly, but Ptolemy accepted the complexity as being necessary to explain what could be seen, or to "save the appearances."




Ptolemy's system, despite its imperfections, was used for 1,400 years, until the Polish astronomer Nicolaus Copernicus proposed that the planets, including the Earth, orbited the sun in perfect Platonic circles — the "heliocentric" hypothesis. The Copernican theory did not predict celestial events much better than Ptolemy's, and was in any case denounced as heretical by the Inquisition. But it was much simpler and more elegant than Ptolemy's model and gained credence among both scientists and churchmen. Finally, in 1609 A.D., the German astronomer Johannes Kepler published his *New Aetiological Astronomy or Celestial Physics together with Commentaries on the Movements of the Planet Mars*, demonstrating what are still known as the first and second laws of planetary motion.

Working from meticulous data compiled by Tycho Brahe, his predecessor as the imperial court astronomer, Kepler had sought for nine years to determine the orbit of Mars, the planet whose movements were least predictable under both the Ptolemaic and Copernican systems. Comparing the relative positions over time of the Earth and Mars, it eventually came clear to him that the Martian orbit, and those of the other planets as well, must be described not as a circle but as an ellipse with the sun at one focus (the first law) and with each planet moving faster nearer the sun, sweeping equal areas of its orbital plane in equal times (the second law). At last the mystery of the apparent retrograde movement of Mars had been solved.

*Kepler explained the apparent retrograde motion of Mars, which seems to reverse course in the sky because the two planets are moving at different speeds along elliptical, not circular, orbits.*

**PTOLEMY:**

**"Let no one, seeing the difficulty of our devices, find troublesome such hypotheses. . . . It is proper to try and fit as far as possible the simpler hypotheses to the movements in the heavens; and if this does not succeed, then any hypotheses possible. Once all the appearances are saved by the consequences of the hypotheses, why should it seem strange that such complications can come about in the movements of heavenly things?"**

# The eerie canals

WAY OUT

Mean distance to the Sun:

Mars:
227,900,000 km
141,617,000 mi

Earth:
149,600,000 km
92,900,000 mi

Beginning with Galileo in 1610 A.D., scientists — and everyone else with access to the newly invented telescope — could look at Mars with new eyes. Over the next century, through the work of Galileo, Fontana, Huyghens, Cassini, and others, it was discovered that Mars rotates on its own axis in about 24 Earth hours and has polar caps that advance and recede.

In the 18th Century, William Herschel in England calculated the Martian day at 24 hours, 39 minutes, 22 seconds, only 13 seconds shorter than the currently accepted period. Herschel also determined that the incline of the Martian axis of rotation, the imaginary line between the north and south poles, was 24°, just half a degree more than Earth's. The axial incline shows different faces of the planet to the sun as it proceeds in orbit, producing seasons — about twice as long as seasons on Earth, since the Martian year is 687 days compared to Earth's 365. Herschel noted what appeared to be clouds in the Martian atmosphere and speculated that the rapid changes in the polar caps meant that the ice cover must be thin — again anticipating the modern understanding.

It was toward the end of the 18th Century, however, that some significant misconceptions about Mars began to creep into scientific thinking and take hold of the popular imagination.

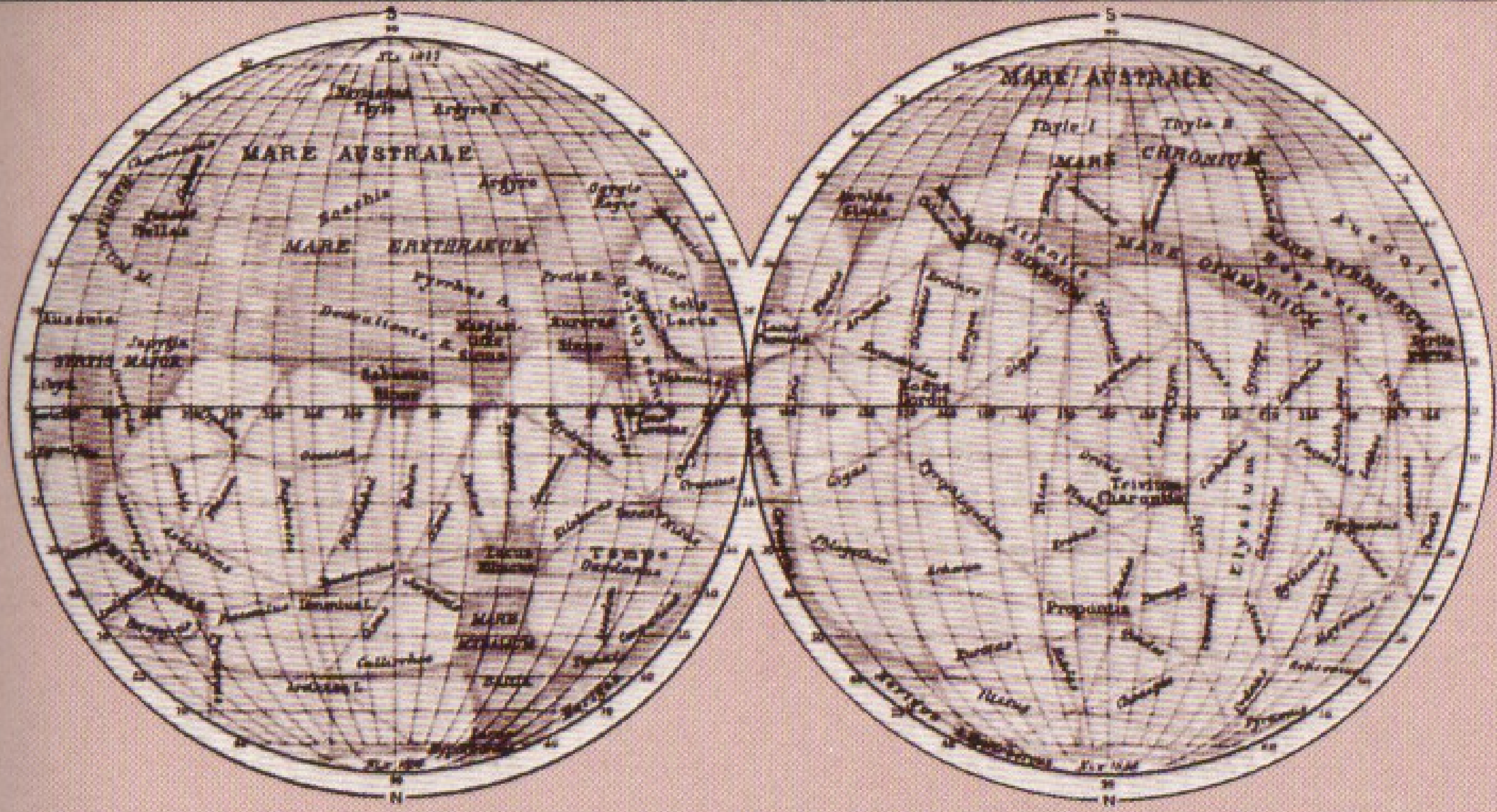
The presence on the reddish Martian surface of large dark areas and the seasonal recession of the polar caps suggested the existence of water. Between 1877 and 1888, Giovanni Schiaparelli published a series of highly suggestive and hugely influential maps of Mars, showing the supposed seas or *maria* of the southern hemisphere and a network of crisscrossing lines which seemed to him "the finest threads of a spider's web drawn across the disk" of Mars. Following the terminology earlier used by the Jesuit Pietro Angelo Secchi to describe the faint markings he discerned on the Martian surface, Schiaparelli called these lines *canali*, a word with many meanings in Italian, but fatefully taken into English as"canals."

## Martian Civ 101

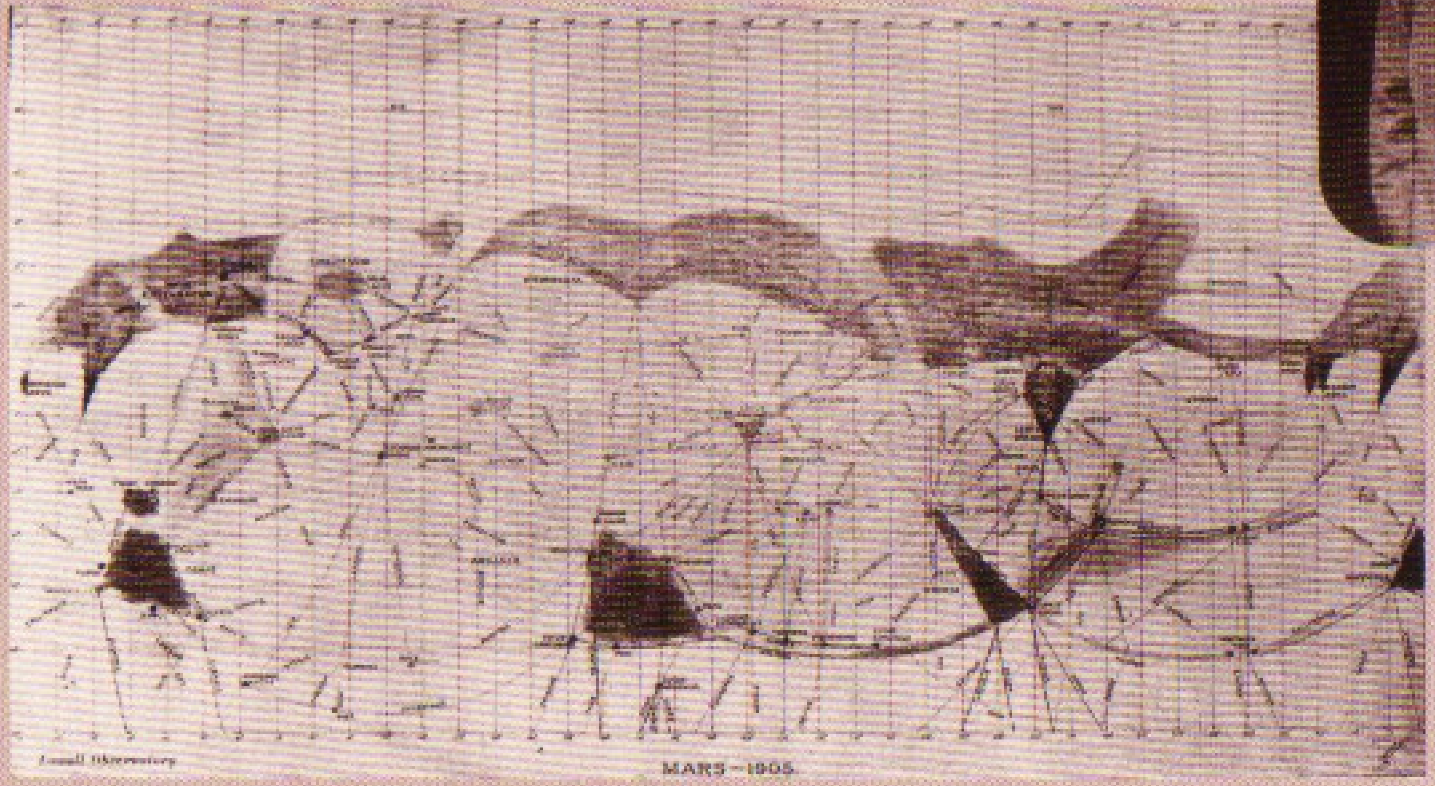
As the notion of Martian "canals" spreadthrough the scientific and popular literature, the wealthy, patrician American astronomer Percival Lowell (his brother Abbott was president of Harvard and his sister was the poet Amy Lowell) became convinced that these markings were "massive irrigation systems" carrying water from the polar ice caps to far-flung equatorial outposts of the remnants of Martian civilization, creatures desperately trying to survive the desiccation of their dying planet.

To explore the canals in the face of skepticism from such prominent astronomers as E.E. Barnard of Lick Observatory and George Ellery Hale of Yerkes, in 1894 Lowell founded his own observatory near Flagstaff, Arizona. During the next fifteen years he published three popular books (*Mars and Its Canals*, *Evolution of Worlds*, and *Mars as the Abode of Life*) detailing his theory that the canals could have been built and maintained only by an advanced civilization that had forsaken war.

Although scientific opinion during the next half-century settled on the interpretation that the canals were an optical illusion — a mind's-eye trick of involuntarily connecting the barely-perceptible dots of surface features that could be observed through telescopes — the popular press, literature, and films kept alive the alternately frightening and hopeful idea that there were Martians whom we might one day meet.




Courtesy Lowell Observatory




*Giovanni Schiaparelli's 1892 map of Mars (above) ncluded lines representing apparent features that he alled* canali. *The American astronomer Percival owell (inset, right) believed these were literally anals dug by Martian engineers, a hypothesis he xplored in several popular books. A map produced y Lowell in 1905 is shown below. As a result of such peculations, the English language is comfortable vith the notion of a "Martian" or a "man from Mars," ut not with any word for comparable creatures from ther planets in the Solar System.*

**THICK**

**Diameter at the equator:**

**Mars:**
**6,786 km**
**4,217 mi**

**Earth:**
**12,757 km**
**7,927 mi**

**Ganymede:**
**5,600 km**
**3,480 mi**

**Callisto:**
**5,216 km**
**3,241 mi**

**Moon:**
**3,476 km**
**2,160 mi**

# The space age

SPEEDY

Mean orbital velocity:

Mars:
24.1 km/sec
53,964 mi/hr

Earth:
29.8 km/sec
66,600 mi/hr

With the advent of space flight in the 1950s and '60s, the science-fiction fantasy of travel to Mars became a plausible (though complex and expensive) engineering project. Mars exploration was among the objectives of both the American and Soviet space programs. Between 1965 and 1976, the two countries each flew six missions to Mars. The Soviet missions were largely unproductive, with only the short-lived orbiter *Mars 5*, in 1974, relaying useful data.

Initial results from the first U.S. mission, *Mariner 4* in 1965, were hugely disappointing both to the romantics who had hoped to find evidence of conditions that could support life, and to scientists who had expected merely that Mars would present an active and varied geological environment. Instead, the 22 photographs relayed by *Mariner 4* as it flew by Mars suggested that the red planet was as dead as our moon, a barren, cratered land where nothing much had happened for billions of years.

*Mariner 6* and *Mariner 7*, both launched in 1969, returned some 200 photographs that amplified but did not change the picture of Mars gathered from the previous fly-by. The northern hemisphere appeared to be dominated by large plains with few craters, in contrast to the heavily gouged and cratered appearance of the southern hemisphere. The atmosphere was found to consist largely of carbon dioxide, $CO_2$, that can freeze in the polar regions during winter, when temperatures fall to as low as –120°C (–184°F). Frozen carbon dioxide is dry ice, which settles out on the surface, then vaporizes in the summer, producing the commonly observed rapid seasonal changes in the size of the polar caps.

Of great significance for both geology and biology, atmospheric pressure is merely one percent of Earth's, so that ordinary water, $H_2O$, cannot exist in liquid form on the surface: If it doesn't freeze, it must instantly evaporate. Liquid water may however exist underground.

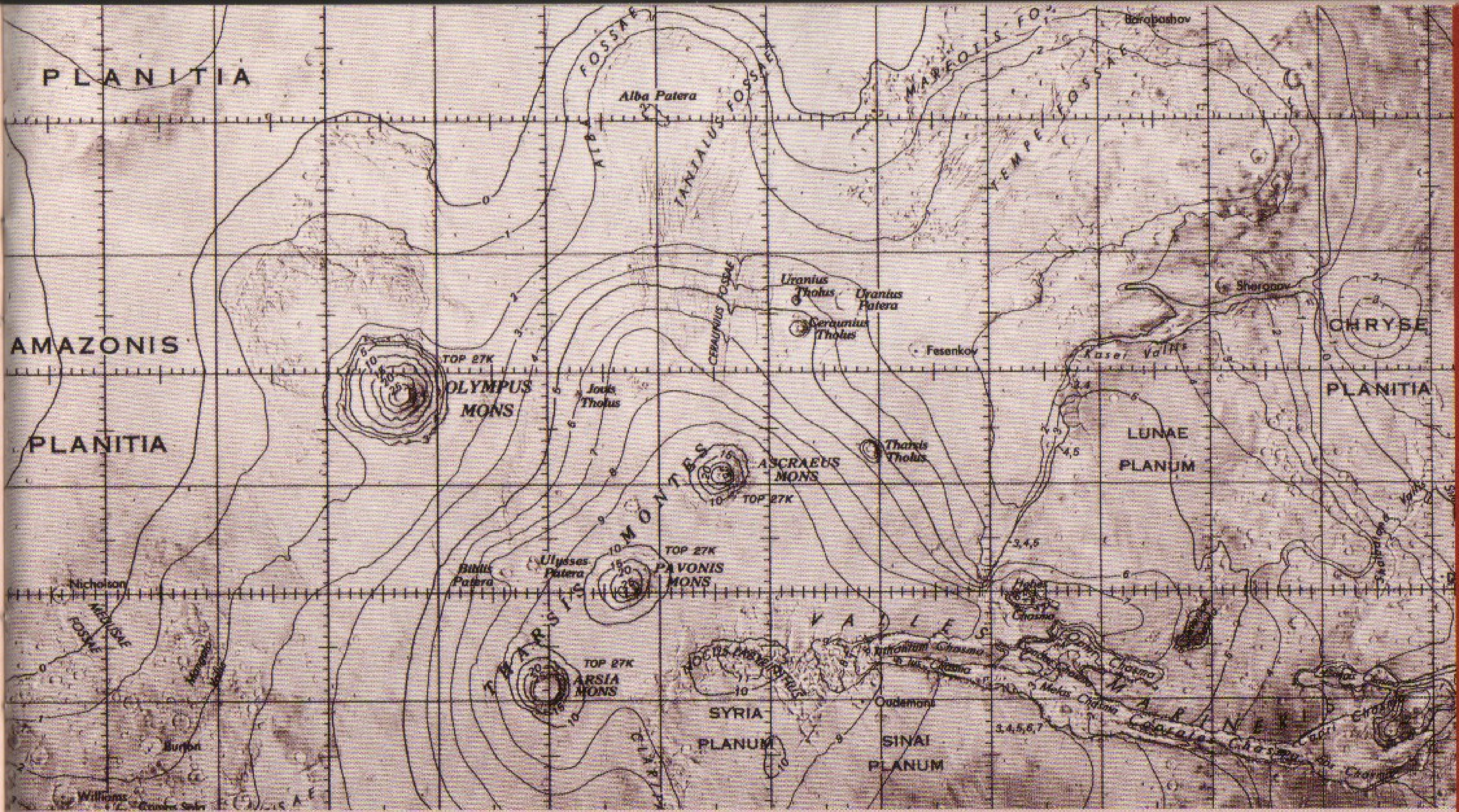
## Revelation: Mariner 9

In contrast to its predecessors, *Mariner 9*, launched in 1971, did not keep going once it had encountered Mars — it was put into orbit and remained in orbit for nearly one Earth year. It carried more sophisticated instruments. And what it reported back to Earth was astounding.

When the spacecraft arrived at Mars on November 14, 1971, an enormous dust storm had blanketed the planet. Nevertheless, what appeared to be four volcanic craters in the region of Tharsis (15°S to 15°N latitude, 105° to 135°W longitude) jutted above the dust, and by January, when visibility improved greatly, the Martian landscape proved to be considerably more dramatic and varied than had been indicated by the earlier exploration.

The four major volcanoes in Tharsis, for example, are immense. The largest of them, Olympus Mons, is 550 km (330 miles) in diameter at its base, parts of which rise 6 km (3.5 miles) in steep cliffs from the surrounding plain, and its summit is 25 km (15 miles) high — nearly three times as high as Mt. Everest.

*Mariner 9* also transmitted breathtaking pictures of a canyon, or rift valley, that dwarfs any comparable formation on Earth. Valles Marineris, named for the spacecraft, runs some 4,000 km (2,400 miles) east to west just south of the Martian equator, and at its widest point, about 70°W, encompasses three parallel chasms 700 km (420 miles) across and as much as 7 km (4.2 miles) deep. On Earth, the Grand Canyon of the Colorado stretches 450 km (270 miles), is 30 km (18 miles) across, and 2 km (1.2 miles) deep.




*The amazing topography of Mars is evident in this U.S. Geological Survey map showing the gigantic volcanoes of the Tharsis Bulge and the east-west chasms of Valles Marineris. For scale, the caldera of Olympus Mons, shown in the photo above left, is 90 km (56 mi) across.*

USGS

**DAILY**

**Period of rotation:**

Mars: 24 hr, 37 min, 23 sec
Earth: 23 hr, 56 min, 4 sec

NO QUESTION

Sergei Kapitsa, moderator in Moscow for the Spacebridge telecast between US and Soviet space experts, ended the program by declaring:

"In the last analysis, we are flying to Mars to better understand the history and future of our own planet. This is a search for fundamental knowledge and understanding of what is going on. It is knowledge that belongs to all of

(continued opposite)

# The Vikings

Because Mars and Earth are "in opposition" — nearest each other in their orbits — only for about a month every two years or so, the next opportunity for exploration was in the spring of 1974, when the Soviets launched four spacecraft, including two that were to land on the Martian surface; unfortunately, because the Soviet craft could not be reprogrammed once in flight, only the orbiter *Mars 5* completed its mission, making 20 revolutions at an altitude of 1,500 km (900 miles) and relaying 70 photographs and other telemetric data.

The U.S. space program continued with the summer 1976 opposition. *Viking 1* and *Viking 2* were combined orbiter-landers whose principal mission was to look for signs of life. When *Viking 1* arrived in June it flew for a month searching for a suitable landing spot, and the lander parachuted to the surface at Chryse Planitia on July 20, 1976, the seventh anniversary of Neil Armstrong's first steps on the moon. *Viking 2* arrived in August, settling on Utopia Planitia.

The two orbiters systematically mapped the Martian surface and the landers photographed the landscape and analyzed the soil. The *Viking 2* orbiter functioned until 1978 and the *Viking 1* orbiter until 1980. The *Viking 2* lander functioned until 1980 and the *Viking 1* lander until 1983. They found no sign of even primitive or extinct life-forms. The possibility remains that these may exist elsewhere on the planet.

## Destination Mars

The Soviets, meanwhile, planned a major probe of Mars and its moons for the 1990s. Two orbiter-landers, *Phobos 1* and *Phobos 2*, were launched in July, 1988 for scheduled contact in April of 1989. They were to skirt within 150 feet of the surface of Phobos, the larger of Mars's two moons, drop probes to the ground, then continue to Mars orbit and lander activities.

The Phobos mission was designed to be but the first of several with Soviet spacecraft carrying experiments and instruments designed by scientists from many countries, including the United States.

(In September, 1988, on its way to Mars, *Phobos 1* lost power, apparently due to a computer problem on Earth that left the craft unable to orient its solar-collector panels toward the sun. *Phobos 2* also malfunctioned, and was lost in March, 1989.) The U.S. and the U.S.S.R. signed a five-year treaty for cooperation in nonmilitary space research in 1987; President Reagan and the Soviet leader Mikhail Gorbachev agreed on additional cooperative measures in May, 1988.

Among other things, the American spacecraft

*Left, U.S. participants in the Spacebridge at Boulder, Colo., included planetary scientist Carl Sagan, left. Below, the program logo. At right, a painting of impact on Mars.*

Photos courtesy the Planetary Society and KCET-TV
Painting by Michael Carroll


*Mars Observer*, scheduled to go in Mars orbit in 1992, would relay data from a French-Soviet balloon floating just above the Martian surface, one of the objectives of a Soviet mission scheduled for 1994. There are tentative plans for additional launches in the 1990s, including one in the year 2000 that would bring samples of Mars soil back to Earth for analysis.

And both Soviet and American scientists have been actively discussing a joint manned mission to Mars. In July, 1987, the Planetary Society organized a four-hour "spacebridge" meeting over a satellite link between American experts gathered in Boulder, Colorado and their Soviet counterparts in Moscow.

Former astronaut Brian O'Leary has published an annotated scenario for such a venture, *Mars 1999*, in which he argues that it's easier and less expensive to get to and from Phobos than it is to land and take off from the Moon (it just takes a lot longer). And Dr. Valery L. Barsukov, chief of the Soviet delegation to the space-cooperation negotiations in Washington, said in 1988 that a manned Mars flight, probably launched from a Moon base, is "inevitable" early in the next century.

**mankind, and the results of the Mars expedition should belong to everyone. There are no secrets here except for the secrets of nature itself, and to discover those we are setting off for Mars. I should like to end by removing that question mark which popped up at the end of the title to [this] broadcast, 'Together to Mars?'"**

CHECK IT OUT:

*The Surface of Mars*
By Michael H. Carr
Yale University Press
232 pp. (1981)

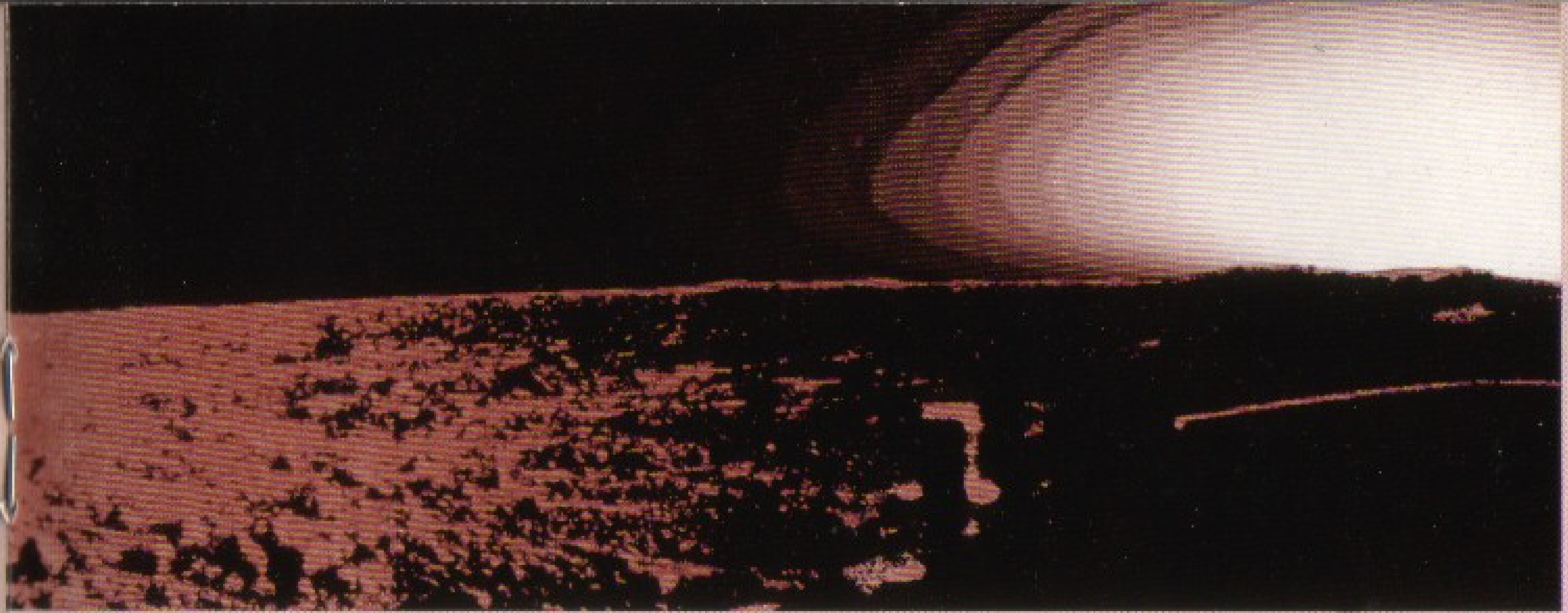
# The red planet: inside & out

The characteristic reddish-orange color of Mars has been known for centuries. The reason for its coloration has not been known, though a good guess would have been high concentrations of iron oxides — the components of rust — in the soil. The guess is probably correct.

Analysis of the soil at the two widely-separated Viking lander sites in Chryse Planitia and Utopia Planitia shows that ferric oxide, $Fe_2O_3$, constitutes 18 to 20 percent by weight of both the loose topsoil and the compacted duricrust. The topsoil is probably the same or very similar everywhere on the planet because of the frequent planet-wide dust storms. Magnesium and sulfur oxides are also relatively abundant, and aluminum and silicon relatively scarce, as compared to Earth's surface. (Mars soil is, nevertheless, 45 to 50 percent silicates by weight.)

While there is no surface water on Mars, there is water bound in the soil minerals which can be released by heating — an experiment performed by the Viking landers — and some atmospheric water vapor that condenses in the form of frost and evaporates in the sun's warmth. It is

*Looking northeast from the Viking 1 lander in Chryse Planitia. The landscape is dominated by drifts of fine-grained materials.* (NASA)



*Computer-enhanced Martian sunrise over the landing site of Viking 1 at Chryse Planitia.* (NASA)

apparently frost that accounts for at least some of the contrast between bright and dark areas (albedo markings) that are noticeable even with low-power telescopes from Earth.

There is also water in the form of ice beneath the polar caps and in permafrost layers beneath the Martian surface, and there is evidence, discovered by the *Mariner 9* and Viking missions, that flowing water created a large number of what appear now to be dry riverbeds. These "channels," as they are called, to distinguish them from "canyons" created by geological faulting and from the nonexistent "canals," run from high to low ground, flow around teardrop-shaped islands, and end in low-lying basins. Unlike riverbeds on Earth, however, the larger channels typically start abruptly in areas of collapsed, or "chaotic," terrain.

The channels have led some interpreters of the Mariner and Viking data to speculate that at some time in the past, perhaps as much as three billion years ago, the Martian atmosphere was warm and dense enough to permit rain to fall and liquid water to accumulate on the surface. Over time, as Percival Lowell imagined, the atmosphere thinned until it consisted mainly of low-pressure carbon dioxide, desiccating the surface.

Another possibility is that channels may have formed in flash floods, when water in the permafrost was released by volcanic activity. In this scenario, molten rock intrudes through the crust, melting the subterranean ice, which erupts to the surface in geysers, causing slurries of water, rock, and dust to flow down the mountainsides.

At the poles, and of much more recent geological vintage, water and carbon dioxide have helped form a bizarre swirling terraced landscape that undergoes continuous reshaping with the weather. The principal area of layered terrain at the north pole is called Chasma Boreale, and at the south pole Chasma Australe. In the southern summer the $CO_2$ frosting of the polar cap virtually disappears entirely, exposing and highlighting the terraces.

The terracing is apparently caused by wind-blown deposits of dust accumulating on layers of soil in which are sandwiched sheets of water-ice and dry ice (frozen carbon dioxide). As the warming sun causes the ice to evaporate, sections of ground collapse, perhaps in isotherms. The steps range from 10 km to 50 km (6 to 30 miles) deep and from 100 to 1,000 meters (330 to 3,300 feet) high.

**CHECK IT OUT:**

***Planets and Moons***
**By William J. Kaufmann III**
**W. H. Freeman and Co.**
**219 pp. (1979)**

# North vs. South

TILT

Inclination of equatorial plane:

Mars: 23 59'
Earth: 23 57'

*Mariner 9* recorded the considerable disparity between the northern and southern hemispheres of Mars. Many large impact craters mark the southern hemisphere, while the northern hemisphere is dominated by vast plains, including the Elysium and Tharsis bulges — masses of continental proportions created by lava flows from the giant volcanoes.

Why this should be so is not definitively known. The preferred interpretation has to do with the cessation of tectonic activity early in Mars's geological history. "Plate tectonics" refers to the movement of a planet's crust over its mantle (which surrounds the core); on Earth, this process created, and continues to create, islands, continents, and mountain ranges.

On Mars, tectonic movement stopped when the crust thickened some 3.9 billion years ago. The period of heavy meteorite cratering had already come to an end. After that time, molten material from the interior of the planet could come to the surface only through a few vents whose location in the northern hemisphere never changed. Those vents continually built up the same few volcanic peaks and spread lava over the plains, filling in and covering over the northern impact craters.

As a result, Mars has twelve volcanoes larger than any on Earth. The largest, Olympus Mons, would cover all the territory from San Francisco to Los Angeles and east to Las Vegas. Three times higher than Mount Everest, it may still be growing.

By the same token, the main trenches of Valles Marineris, the enormous sub-equatorial canyon system southeast of Tharsis, were most likely produced by faulting, a result of tectonic movement. On Earth, continued tectonic activity would probably have widened the "canyon" into something like the Arabian Sea. But since the cessation of tectonism, Martian topography has been modified mainly by volcanic eruptions, by landslides, by fracturing due to the enormous weight of the Tharsis bulge, and by the scouring action of frequent wind and dust storms of hurricane force.

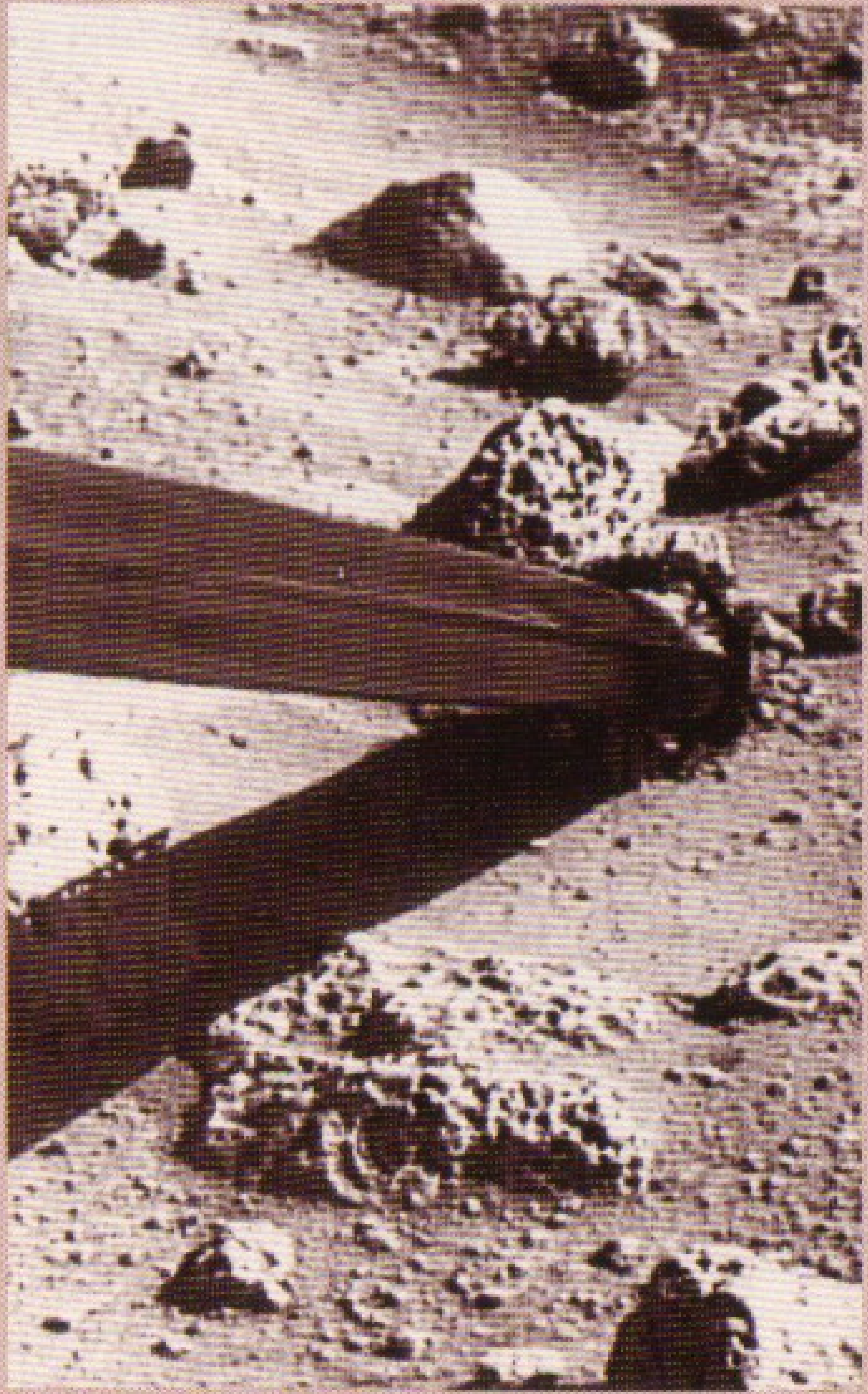
*There are no "canals" on Mars but there are channels, probably cut by running water more than 3.5 billion years ago. The planet's climate and atmospheric pressure do not now permit water to exist in liquid form at the surface. Here, flow from the lower left diverged around crater walls, creating teardrop-shaped islands.*

NASA photos

# Life on Mars?

The Viking landers were programmed to systematically probe their immediate environments for signs of life by examining the soil for microorganisms and organic chemistry. And the Vikings carried wide-angle cameras to snap the terrain through the seasons, "just in case," as the planetary scientist Carl Sagan once put it — "just in case a silicon-based giraffe should happen to wander by."

Although interesting chemical reactions mimicking organic processes were obtained by the Viking instruments, the conclusion was inescapable that no form of life or carbon-based organic compound exists at the lander sites in Chryse Planitia and Utopia Planitia.



*And nothing crawled out from under: A probe from the Viking 2 lander pushes aside a rock to obtain soil samples not exposed to solar radiation. The soil was analyzed for evidence of biological or biochemical activity, but none was found.*

Dr. Harold P. Klein, director of life sciences at NASA's Ames Research Center, cautions nevertheless that the Viking sites may not be completely representative, and the possibility of non-carbon-based life cannot be excluded, though it is extremely remote.

"Mars today," he has said, "still has chemicals on its surface, an atmosphere, temperatures and pressures, within which we believe life can exist."

**OUTTA HERE**

**Escape velocity:**

**Mars:**
**5.0 km/sec**
**11,232 mi/hr**

**Earth:**
**11.2 km/sec**
**25,200 mi/hr**

**ANNUAL**

**Period of revolution:**

**Mars: 687 days**
**Earth: 365 days**

# PhD: The moons of Mars

Phobos and Deimos, the tiny Martian moons, are often described as "potato-shaped," and indeed the odd contours of these bodies suggest chips off some great cosmic rock rather than worlds shaped by planetary forces like our moon.

The first good pictures of Phobos and Deimos (sometimes collectively referred to as PhD) were taken by *Mariner 9* in 1971, almost a century after their discovery by Asaph Hall of the U.S. Naval Observatory during the 1877 opposition — the same period of "good seeing" in which Schiaparelli mapped the supposed Martian "canals."

Phobos, the larger of the two, is even so a mere cosmic speck of very dark, cratered rock, approximately 27 x 21 x 19 km (16 x 13 x 11 miles). It orbits Mars at a mean distance of about 5,000 km (3,000 miles).

And Deimos is little more than half as large: 15 x 12 x 11 km (9 x 7 x 6.5 miles). It travels in a near-synchronous orbit some 20,000 km (12,000 miles) above the Martian surface.

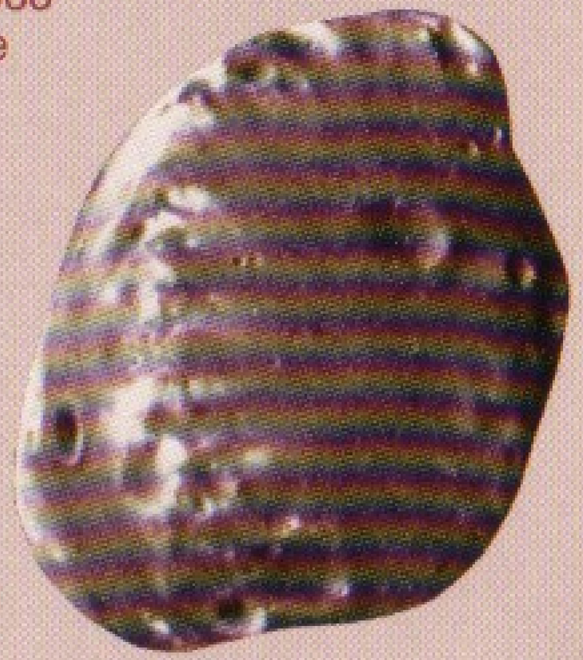
Like Earth's moon, both Phobos and Deimos keep the same face turned toward their planet.

Both travel in near-equatorial orbits. Phobos circles Mars in 7 hours, 40 minutes; Deimos makes its longer trek in 30 hours, 15 minutes.

The gravitational pull of Phobos and Deimos is very small, but not insignificant; this has led some experts to suggest that Phobos would make a better base for exploring Mars, mining the asteroid belt, and creating space-based industry than either a Moon base or a space station in Earth orbit. Escape velocity from Phobos is only 40 miles per hour (64 kmph); one could go into orbit on a bicycle. Landing would be a similarly low-energy enterprise.

Because of their low reflectivity and low densities, considerably less than that of the basaltic rock that characterizes the Earth, the moon, and Mars itself, scientists suspect that both Martian moons are composed largely of carbonaceous chondrites, minerals usually containing carbon compounds and bonded water. If that's so, Phobos and Deimos are most likely captured asteroids which have undergone little or no geological change since the creation of the solar system.

One of the chief tasks of the failed Soviet Phobos mission launched in 1988 was to analyze the soil of Phobos to determine exactly what it's made of. The answer could tell us much about the nature of the solar system before the formation of the planets, about 4.5 billion years ago.



*Deimos, left, and Phobos, approximately to scale.*

NASA photos

# Naming names

Scientific convention has by and large accepted the traditional names of long-known stars and planets, usually taken from classical mythology. In some cases, including that of Mars and its moons, science has adopted nomenclature in the traditional vein.

Mars itself is named for the Roman god of war, equivalent to the Greek god Ares. Asaph Hall, the American astronomer who discovered them in 1877, named the moons of Mars for two of the sons and attendants of Ares — Phobos and Deimos, the personification of the fear (*phobos*) and panic (*deimos*) that can defeat an army.

Olympus Mons, the giant volcano, is the Latin rendering of Mount Olympus, the home of the Greek gods. Chryse Planitia, where *Viking 1* landed, is the Plain of Chryses, a priest of Apollo whose daughter, Chryseis, figures prominently in Homer's *Iliad* as a cause of the feud between Achilles and Agamemnon.

*Viking 2* settled in Utopia Planitia, named for the imaginary island of utmost perfection described by Sir Thomas More in 1516; the name is composed of the Greek elements *ou*, meaning "not," and *tópos*, meaning "place"; Utopia is to be found nowhere.

**NEIGHBORS**

**Distance between Earth and Mars:**

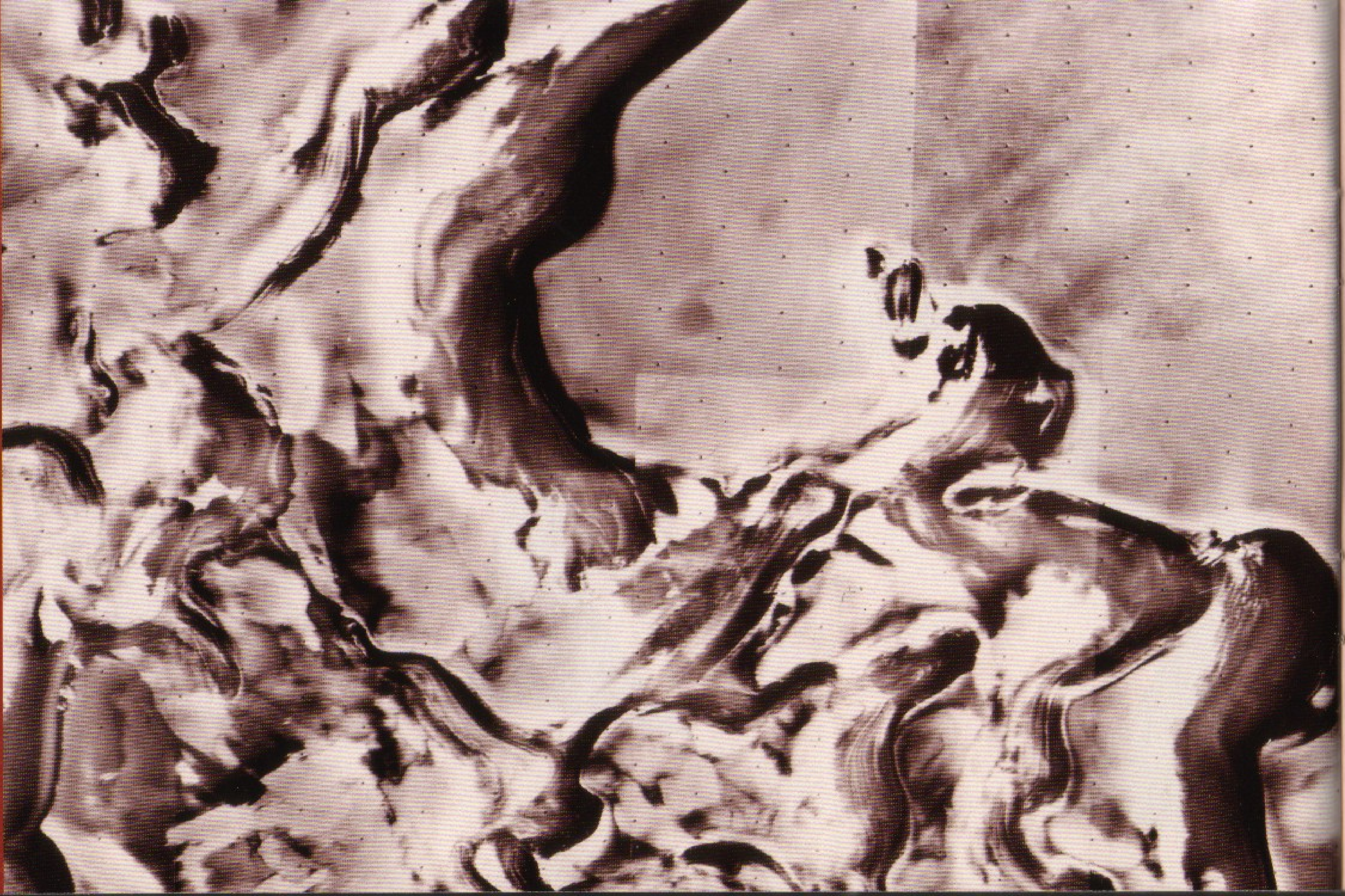
**Maximum:**
**399,000,000 km**
**248,000,000 mi**

**Minimum:**
**56,315,000 km**
**35,000,000 mi**

## POLAR CAPS

A new type of feature never before observed on Mars is seen in this photo-mosaic of the planet's north polar ice cap.

The pictures, taken during Viking Orbiter 2's 56th orbit around Mars show a spectacular array of features caused by the uneven distribution of ice and exposure of defrosted layered material on slopes.



# Viewing Mars

The Earth and Mars are in "opposition" — that is, nearest one another in their orbits — about every 26 months. Because the orbit of Mars is more elliptical than Earth's, some oppositions find the planets closer than others. An especially favorable opposition occurred in September, 1988, with Mars 58 million km (36 million miles) from Earth. The next opposition, not nearly so good, will occur on November 27, 1990.

During the period of best viewing, which lasts about a month, Mars can be seen growing perceptibly larger, which is to say nearer, day by day. Even small telescopes can distinguish the albedo markings, light and dark patches caused by the differential reflectivity of surface materials. (Frost-covered areas reflect more light than unfrosted areas, for example.)

Other highly visible features include the polar caps and the frequent hurricane-force dust storms that scour the planet. In 1988, Mars approached opposition during its southern spring, so viewers were able to track the shrinking of the south polar cap.

## Through a glass, sharply

*Astronomy* Magazine offers these tips for amateurs viewing Mars. Consult the magazine's monthly sky charts or the seasonal tables in VanDam's *The Universe Unfolds* for best viewing times in your location.

**1** Avoid sources of radiant heat — pavements, buildings, rocky and sandy soil, and your own telescope, which should be allowed to cool down to outside air temperature before being used. Radiant heat will distort the image. A level, grassy surface is best.

**2** Make sure your telescope is accurately collimated. Collimation is the precise alignment of optical elements. Refractor telescopes usually have these elements sealed and semipermanently aligned. Reflector telescopes may require adjustment of the mirrors, for which you will need to consult your manual.

**3** If you're using a large-aperture reflector telescope, a makeshift off-axis stopdown mask can enhance the image of Mars at high magnification. For a 17.5-inch 'scope, cut a six-inch-diameter hole in a piece of cardboard large enough to cover the open front end of the telescope.

**4** The highest magnification isn't necessarily best. Use the lowest power that shows all the detail on the planet's disk. Experiment with different settings and eyepieces to get the sharpest view.

**5** Use color filters to improve contrast. Orange highlights albedo markings and dust clouds. Red provides maximum contrast for surface features. Yellow brightens deserts. Green, blue, and blue-green filters darken the deserts and brighten atmospheric features. Violet reveals haze and cloud features.

**6** Take your time. Make a sketch or photos of each day's observation. At least half an hour is recommended; periods of sharper detail will come and go. To sketch Mars, use a 42-mm ($1^3/_4$-inch) circle. Lightly draw in the terminator (where day fades into night) if it's visible, and then what you can see of the polar caps and albedo markings (dark and light areas on the surface). Darken the outlined areas and add any other details that appear. Make a note of the time, date, telescope, magnification, filters, and general viewing conditions.

**LIGHTWEIGHT**

**Objects — or persons — on Mars weigh only 38 percent as much as on Earth.**

*MIR I DRUZHBA*

**"Yet how much could be achieved by the joint efforts of the two planets! Especially if thinking beings from other worlds were to join them."**

**— Ivan Yefremov**
**"The Heart of the Serpent"**

# Two views of the Martians

H.G. Wells's 1898 novel *The War of the Worlds* mesmerized Earthlings in three major incarnations — the original novel, still a widely-read classic of science fiction; Orson Welles's 1938 Halloween radio dramatization, using live-newscast techniques that created panic among hundreds of thousands of listeners who really believed that hostile Martians had landed in New Jersey; and the special-effects Oscar-winning 1953 film starring Gene Barry. Neither human weapons nor wiles could stop the Martians' advance — but they succumbed to an earthly virus.

UPI / Bettmann News Photos

*H.G. Wells*

With a more modern sensibility, Ray Bradbury's equally compelling stories collected in *The Martian Chronicles* (1958) warned of a different danger: the destructiveness of humans, to ourselves and to others. At first the Martians resist the explorers from Earth; then, like the Aztecs and Hawaiians (and like H.G. Wells's invading Martians), they are decimated by the aliens' germs. The first large-scale effort at human colonization of Mars is aborted when the Earth is destroyed in a nuclear war. And at the end of "The Million-Year Picnic," the lone human survivors peer into the rippling waters of a Martian canal to confront, in their own reflections, the progenitors of a new Martian civilization.

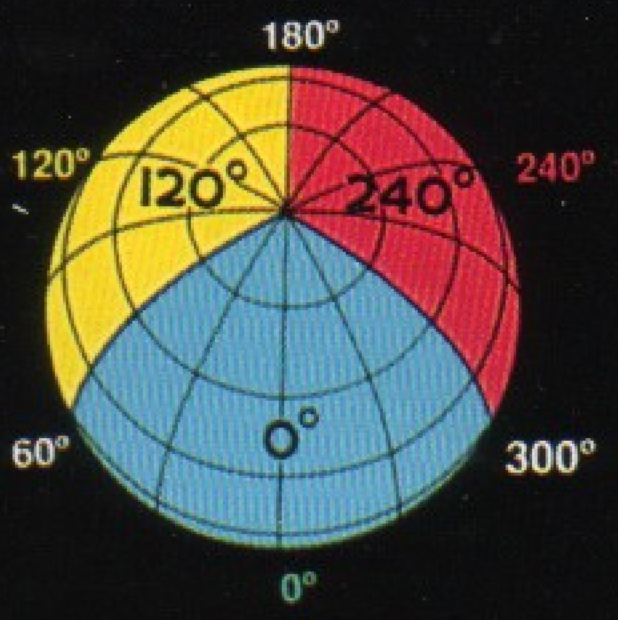
*Ray Bradbury*

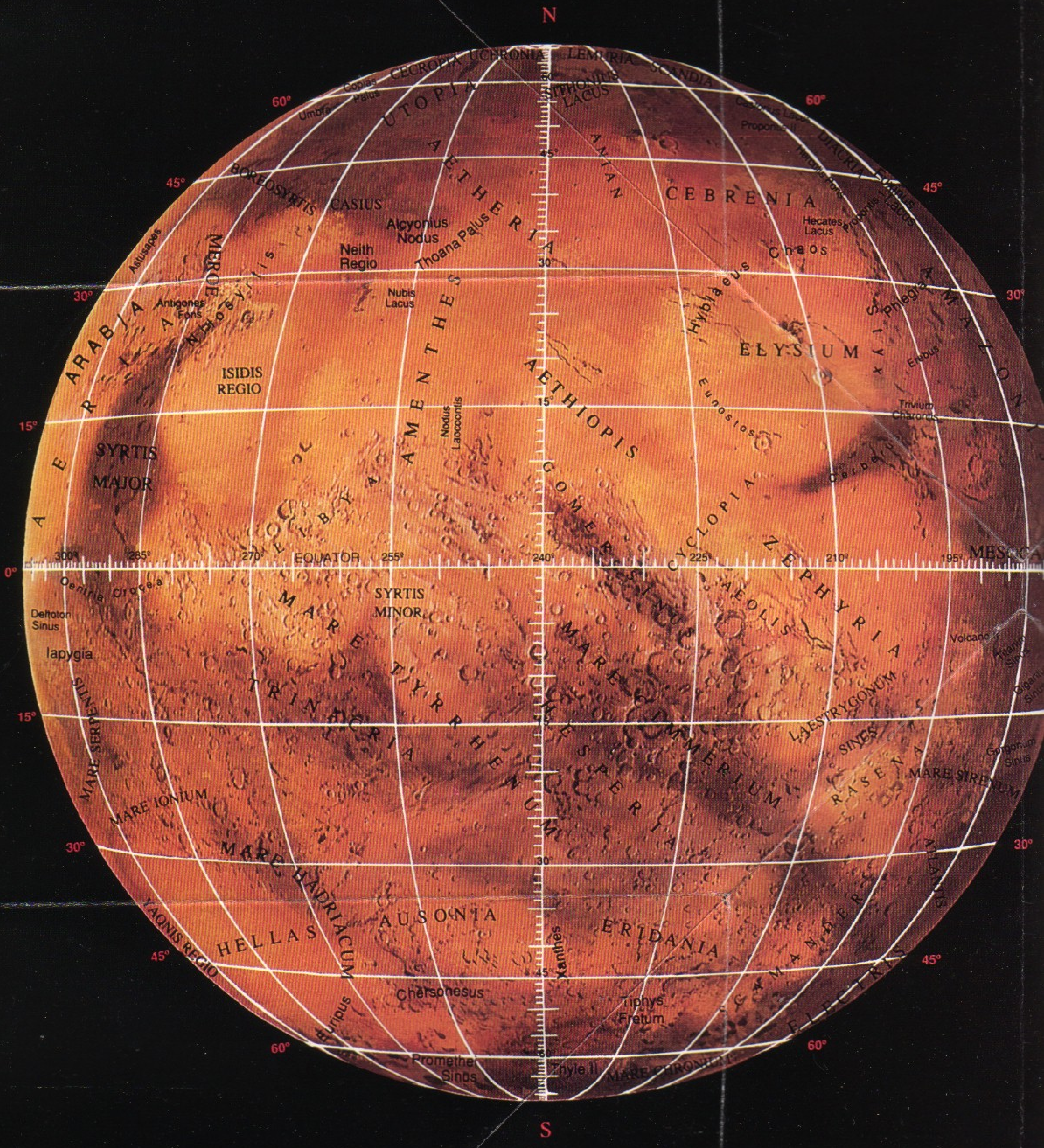
UPI/Bettman News Photos

## ONE EQUATORIAL AND TWO POLAR VIEWS

*The 240° perspective below completes the three equatorial views at a scale of 1:30,200,000.*

*The two polar regions, at right are rendered at a scale of 1:21,800,000 and therefore appear significantly larger than in reality.*

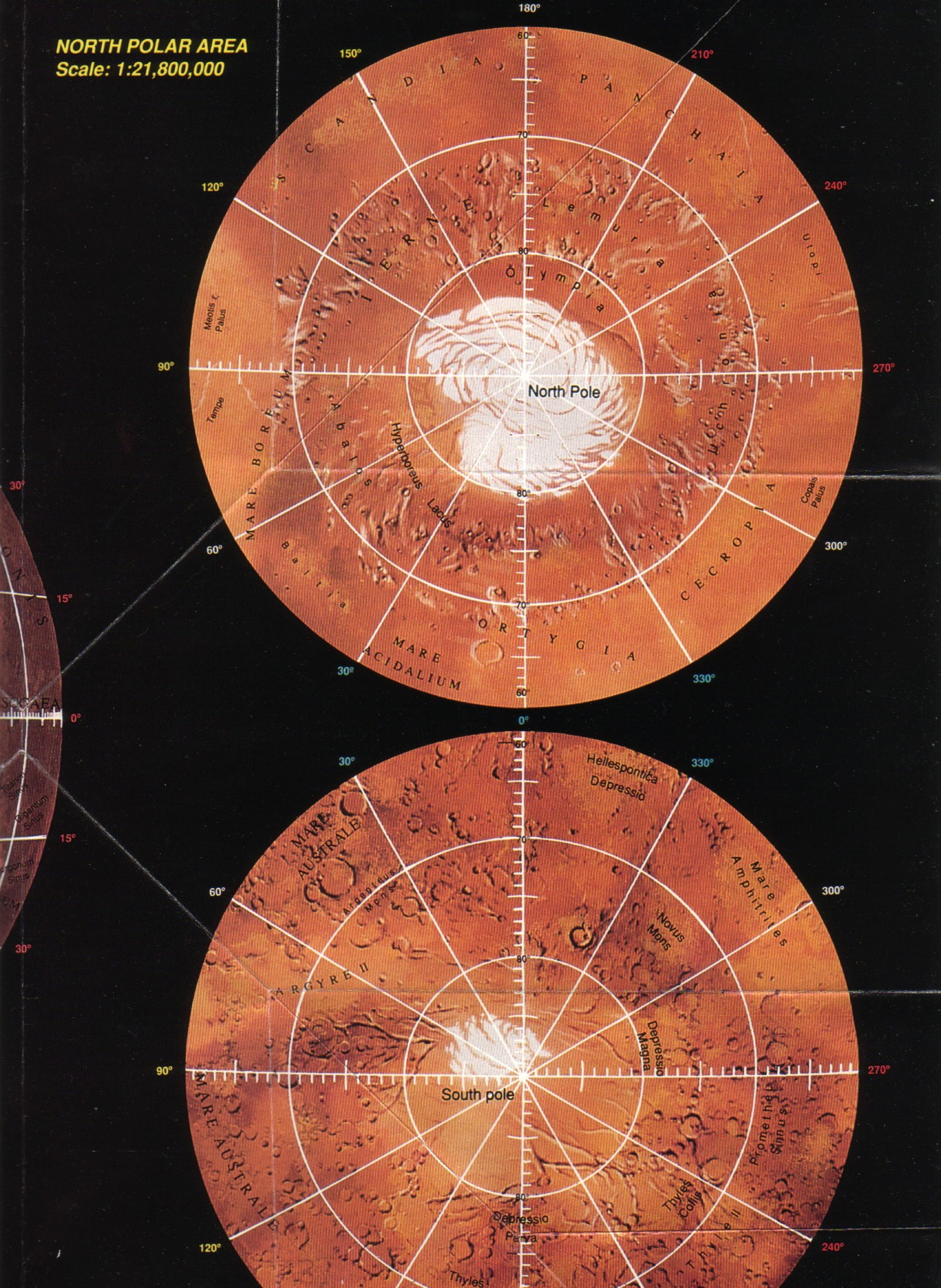



*CENTRAL MERIDIAN 240°*
*Scale: 1:30,200,000*

## MARS -

## NORTH POLAR AREA
**Scale: 1:21,800,000**



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Science/Nature

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