The Sandy Face of Mars

Astronomers ponder the awesome dimensions of Martian dunelands

By JONATHAN EBERHART

"There are some, King Gelon, who think that the number of the sand is infinite in multitude. . . . Again there are some who, without regarding it as infinite, yet think that no number has been named which is great enough to exceed its multitude."

— Archimedes,
"The Sand Reckoner"

The "number of the sand," as Archimedes put it, has served as a time-honored metaphor for an inconceivably large quantity of almost anything. But an extreme among extremes is to consider the grains of sand on the scale of a planet, and a particularly sandy planet at that.

The huge dune fields of Mars are unique among the extraterrestrial surfaces photographed by planetary spacecraft — unlike either the ice that blankets many outer-planet moons or the bare, solid rock and hardened lava flows typical of Earth's moon, Mercury, Venus and even parts of Mars itself. The Martian dunes also demonstrate the sculpting ability of that ruddy world's winds, a phenomenon otherwise seen only on parts of Earth. True, these dunes fail to match the dramatic splendor of the huge Martian volcano called Olympus Mons (the size of Arizona) or the vast canyon network known as Valles Marineris (as long as the United States is wide). Yet any proper list of Martian spectaculars must include the planet's awesome "sand seas."

Best known from photos taken in 1976 and 1977 by the two Mars-orbiting Viking spacecraft, the dunes sweep across the planet's barren terrain in varying patterns (SN: 10/30/76, p.276; 11/20/76, p.330). But just how much sand do they actually hold? Nicholas Lancaster and Ronald Greeley of Arizona State University in Tempe calculate the total volume of the dunes in the north polar region, where they seem most ubiquitous, at 1,158 cubic kilometers (km^3).

If shaped into a ball, this sand would form a sphere 13.028 kilometers in diameter (a little more than 8 miles). That may seem tiny by astronomical standards, but it would exceed the volume of Deimos, one of Mars' two irregularly shaped moons, for which Thomas C. Duxbury of Jet Propulsion Laboratory in Pasadena, Calif., calculates a volume of about 1,052 km^3. Phobos, Mars' larger moon, amounts to about 5,680 km^3.

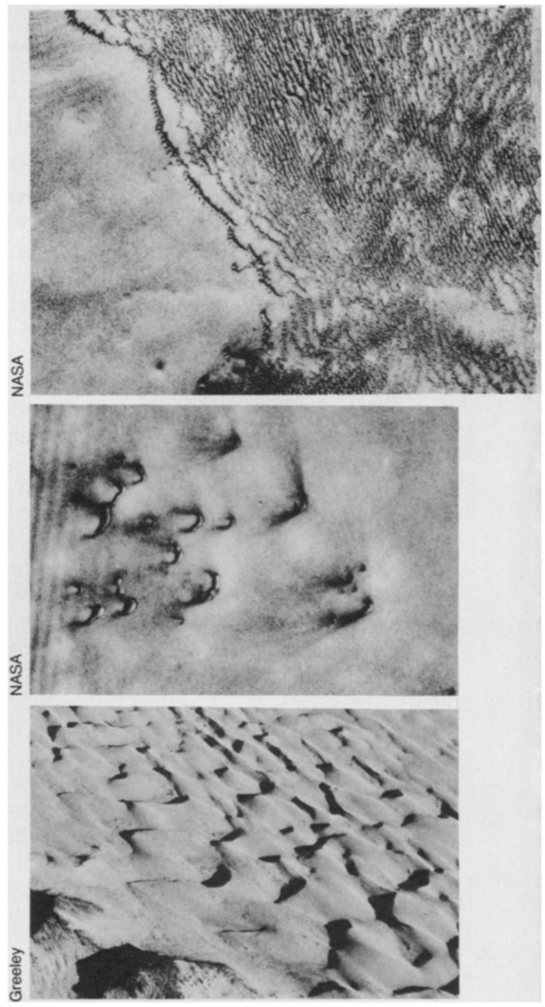
Furthermore, Lancaster and Greeley assert in the July 10 JOURNAL OF GEOPHYSICAL RESEARCH that their dune accounting "should be regarded as a minimum," because they cannot be certain of the depth of the Martian sand seas. Nor does their estimate include the flat stretches of sand separating the dunes.

Dunes dominate about half the total area of the north polar sand seas, most of them rippling the surface in a band between 76° and 83°N latitude. Around part of that band, from 110° to 260°W longitude, lies what Lancaster and Greeley call "the largest continuous area of sand dunes on Mars," covering about 470,000 km^2 — an area the size of Nebraska and Colorado combined. According to the researchers, four major sand seas, totaling 680,000 km^2 — a region slightly smaller than Texas — nearly encircle the north polar ice cap.

Arrayed like threads in a tapestry and scores of kilometers long, Mars' transverse dunes angle across the direction of the dominant winds, with widely varied distances separating successive ridges or crests. Individual dunes, called barchans, appear elsewhere. Winds have sculpted these crescent-shaped features at intervals ranging from less than 200 meters to as much as a full kilometer apart. Lancaster and Greeley say that if the dunes of Mars resemble those of Earth as much as the Viking photos suggest, then the heights of many Martian dunes can be estimated by assuming an approximately Earth-like ratio between their heights and the distances between them. This means that most dunes near the Martian north pole rise between 10 and 25 meters, they say.

On Earth, the scientists note, height-to-spacing ratios of dunes shaped by the wind approximate those of similar features on the bottom of the sea, shaped by deep ocean currents. This suggests that the difference between the density of an atmosphere and that of an ocean has little effect on the dunes' overall shapes, they conclude. Most desert dune patterns on Earth "are very regular, and vary spatially in a systematic fashion," Lancaster and Greeley say. Thus, there seem to be "similar relationships between dune height, spacing, and equivalent sediment thickness on Earth and Mars."

The origin of the Martian dunes remains unknown. Viking photos show places on the north polar cap marked by alternating layers of light and dark materials, and some scientists propose that winds blowing off the cap carry sand particles south to the dunes. Greeley suggests instead that the sand may have reached the dunes by traveling north.



Top: A swath of Martian transverse dunes. Lower photos show barchan dunes near the Martian north polar cap (middle) and in California's Mojave Desert (bottom).

The cap's darker layers probably consist of fine dust rather than sand, he adds. Fine dust carried aloft by the Martian winds can remain suspended in the atmosphere for months, Greeley says — long enough to settle almost anywhere on the planet. By contrast, wind-blown grains of sand hopping across the rocky surface probably do not get far onto the ice cap.

Besides, he points out, "Dust doesn't make dunes. Sand makes dunes."

Greeley notes that Viking photos show much of the northern hemisphere south of the dunes to be relatively dark (low in reflectivity), similar to the dark layers seen on the polar cap. He and Lancaster calculate that if all the grains in these sand seas originated at the northern ice cap, they would have added 275 meters of material over the polar area now layered with deposits. □