15.6.

Kepler and Mariner 9

CARL SAGAN and JOSEPH VEVERKA
Laboratory for Planetary Studies, Cornell University, Ithaca, New York, and
JAMES B. POLLACK
NASA Ames Research Center, Moffett Field, California

JOHANNES KEPLER invented the two moons of Mars. He argued that since Venus has no moons, the Earth has one, and (as it appeared in his time) Jupiter has four. Mars, at an intermediate position must have an intermediate number of satellites—which he guessed to be two rather than three (Gingerich, 1970). The argument, while consistent with Kepler's lifelong search for astronomical harmonies, does not strike us today as especially compelling. Nevertheless Kepler's argument was not forgotten, and may have been responsible for such literary allusions to the existence of two small satellites as in Voltaire's *Micromegas* and in Swift's *Gulliver's Travels*. His argument therefore may also have provided some of the motivation behind Hall's successful search for the satellites in 1877.

It is remarkable that almost 400 years to the day after Kepler's birth—in early December 1971—the first closeup photographs of the two Martian satellites, Phobos and Deimos, were obtained by Mariner 9, transmitted back to Earth, and there computer-processed to bring out the detail. Typical computer-enhanced minimum range photographs of Phobos and Deimos are shown in Figs. 15.9 and 15.10. (Both pictures contain white dots which are due to transmission noise.) The satellites are revealed to be old, heavily cratered, fractured, low albedo objects of reasonably high tensile and yield strength. They appear to be the product of a complex collisional natural selection. We do not yet know whether they are captured asteroids or debris

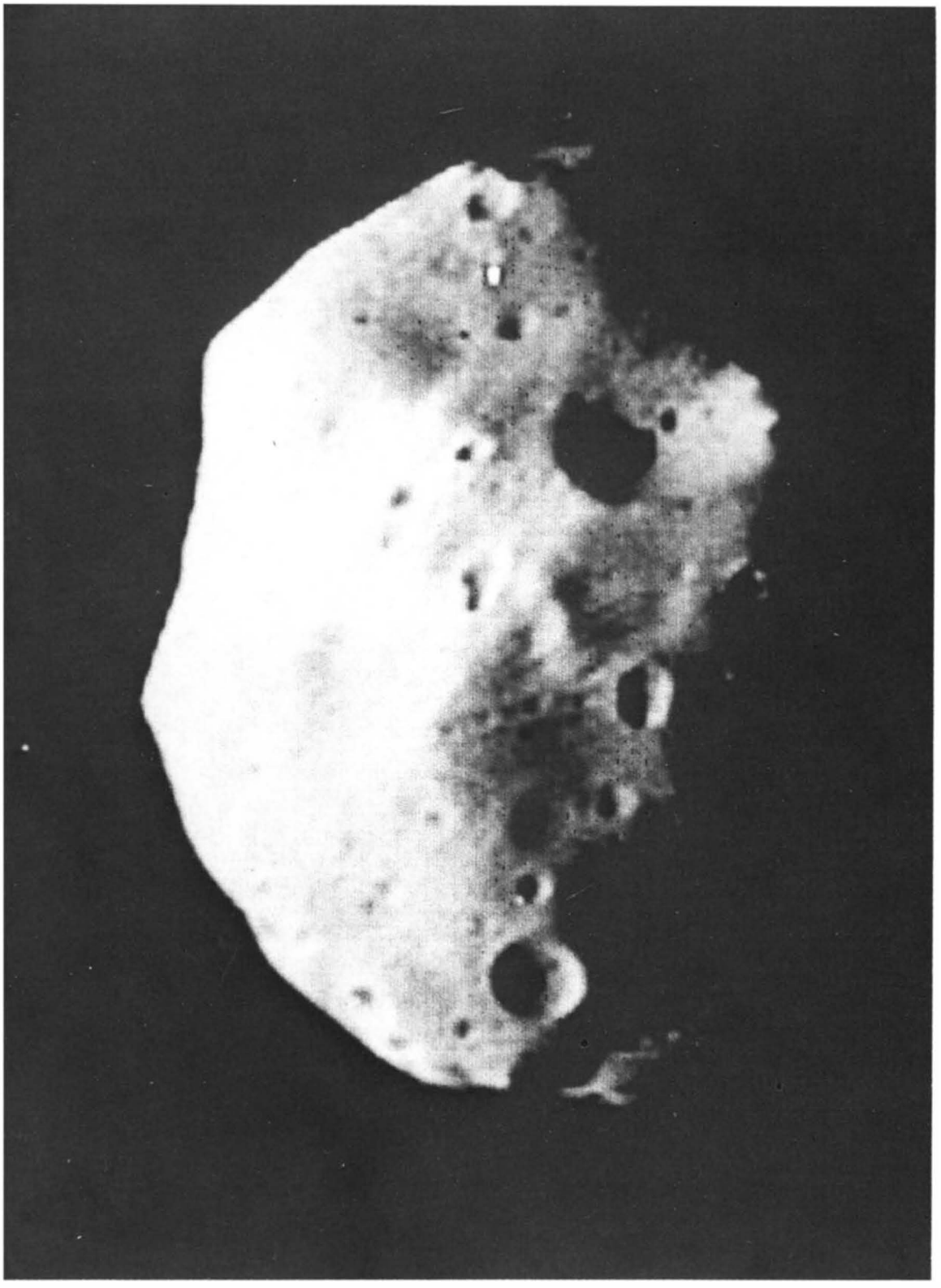

FIG. 15.9. A Mariner 9 view of Phobos from 5758 km. The phase angle is 80°, and the illuminated area is approximately 21 km high and 15 km wide.

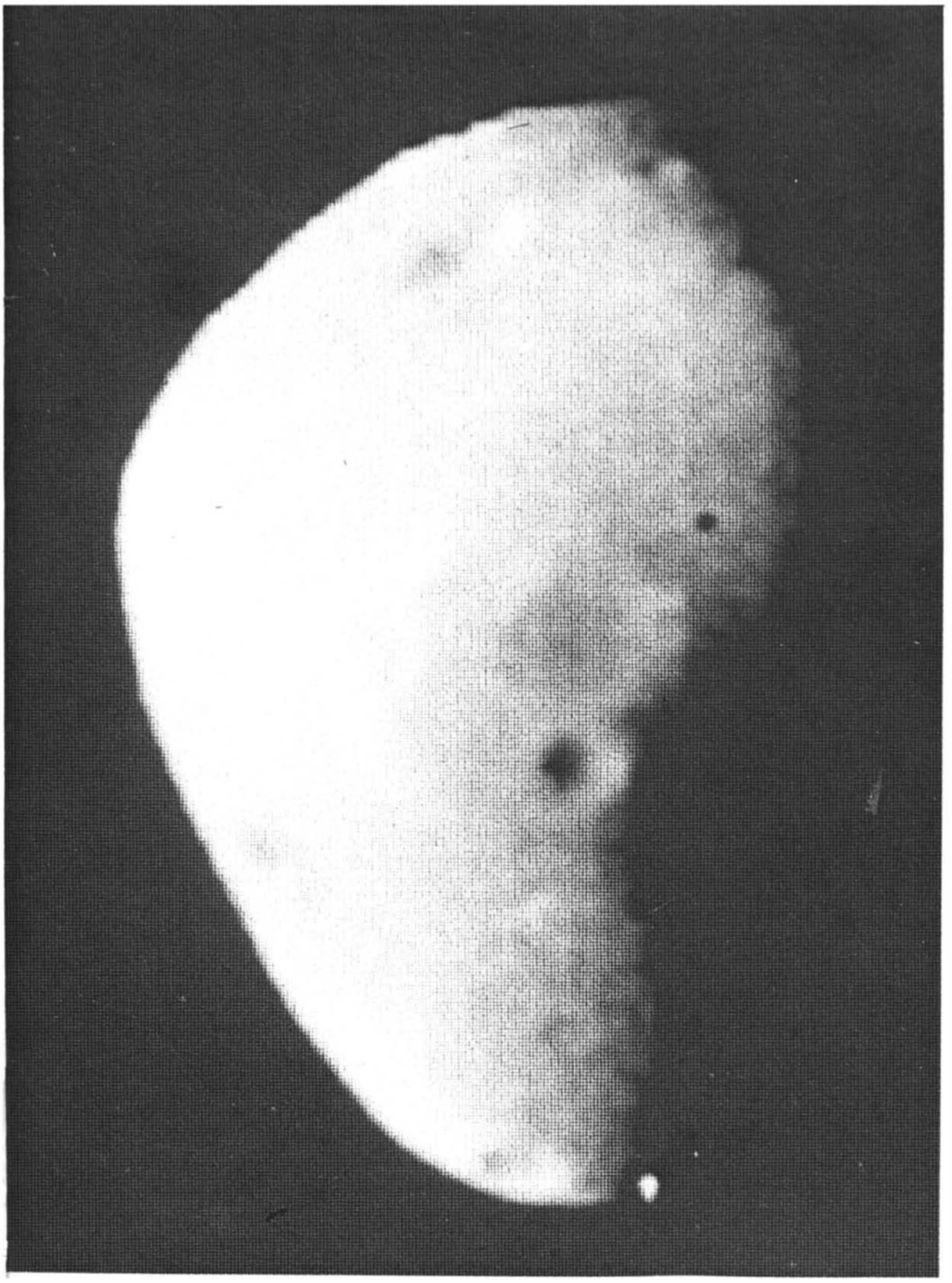

FIG. 15.10. A Mariner 9 view of Deimos from 5465 km. The phase angle is 65°, and the illuminated area is approximately 12 km high and 7 km wide.

left over from the formation of Mars. It does seem quite clear, however, that they are not artificial satellites launched by an ancient Martian civilization as had once been suggested (I. S. Shklovskii in Shklovskii and Sagan, 1966)—an idea which we suspect Kepler would have enjoyed. Because of the absence of aeolian and aqueous erosion on the Martian satellites, they are excellent control impact counters for normalizing the crater densities observed on various parts of Mars, and making preliminary estimates of the ages of Martian terrain features. More details on the preliminary scientific findings about the Martian satellites from Mariner 9 are published in Masursky *et al.* (1972) and Pollack *et al.* (1972).

Kepler, in his *Somnium*, imagined a sort of interplanetary transport but one quite different from that actually used to convey Mariner 9 to Mars. However, the chain of causality from Kepler's laws of planetary motion through Newtonian dynamics and gravitational theory to rocket propulsion and the determination of interplanetary trajectories is quite clear. These photographs of Phobos and Deimos, obtained less than 400 years after these satellites were conjectured to exist by Kepler and less than 100 years after they were observed to exist by Hall, is a dramatic testament to the present vigorous technological civilization on the planet Earth.

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