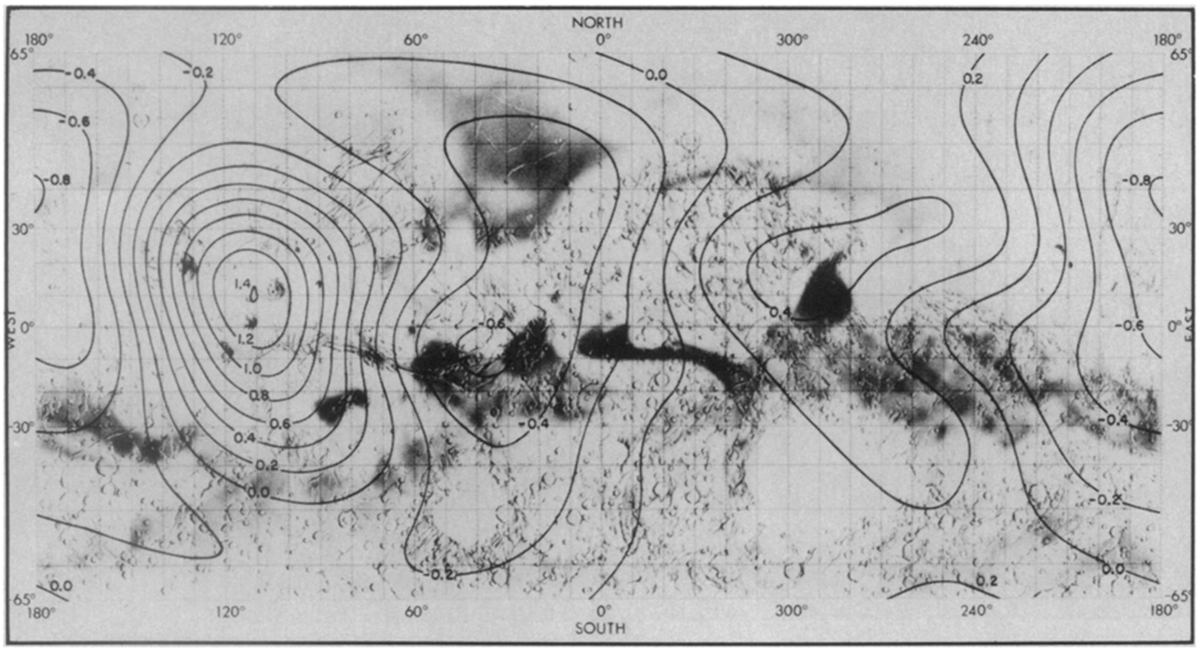
A Matter of Gravity



Reasenberg et al/Geophys. Res. Let.

The newest view of the gravity field of Mars

BY JONATHAN EBERHART

Standing around on Mars, you would notice little or nothing about its gravitational field beyond the striking and refreshing fact that your earth-normal weight had dropped by about 60 percent. Hiking around the planet, you would find that, as on other worlds, its gravity seemed to be the same all over. Not so. Like its topography, magnetic field and heat distribution, the gravitational field of Mars is irregular—slightly but truly, here a little stronger, there a little weaker.

The differences are tiny but significant, affecting studies ranging from the density distribution of the planet to general relativity. One way of expressing these irregularities is in terms of an "equipotential surface"—a theoretical near-sphere showing the local heights (and depths) at which the planet-wide gravitational field would have the same strength everywhere. It shows, in effect, where the bulges and dips would be in sea level if the planet were covered with water.

A group of Massachusetts Institute of Technology researchers have calculated just such a gravity map using tracking data from the Mariner 9 spacecraft. According to them, the highest bulge of this imaginary ocean would be some two kilometers above the lowest dip.

Such models have been made before, point out Robert D. Reasenberg, Irwin I. Shapiro and R.D. White in GEOPHYSICAL RESEARCH LETTERS (2:89), but with fundamental differences. Some early versions suffered "unreasonably large undulations" in the northern hemisphere in part because the spacecraft's closest approach to the planet was at about 23 degrees south latitude. They also embodied data with uneven longitude coverage, the researchers aver, as well as a less effective analysis technique.

A key to the MIT model is that the tracking data that went into it include both short orbital segments measured near the planet and long-period effects accumulated over several orbits. Previous models concentrated primarily on one type or the other, although that of Jet Propulsion Laboratory's George Born (the long-term version, in the JOURNAL OF GEOPHYSICAL RESEARCH 79:4837) added position information based on Mariner 9's television imagery of the Martian moons Phobos and Deimos.

Reasenberg's team used data from six 19-day spans of Mariner's coverage, each timed to let the spacecraft's point of closest approach move across a full 360 degrees of longitude on the planet below. The task was made harder by the need to compensate for leaks and imbalances in the gas jets used to orient the spacecraft—"It staggered like a drunk in the night," says Reasenberg—as well as for the physical pressure of solar radiation, both directly from the sun and reflected from Mars itself.

The result, however, is a sixth-order map of the Martian gravity field, accurate, according to its authors, to within 100 meters below 60 degrees north latitude and to within 300 meters above that. The uncontested high spot of the equipotential surface is in the region of the Tharsis mountains, southeast of the huge extinct volcano known as Nix Olympica (which makes little impact on the map). The east-side "dent" in the contour lines circling Tharsis is probably related to the vast canyons known, after Mariner 9, as the Valles Marineris. The other conspicuous "high" (near 285° W) and the reigning "low" (about 35° W) "all seem to be manifestations of the Tharsis construct."

The map will doubtless be used in a variety of studies—Reasenberg, Shapiro and JPL's John D. Anderson are already using it to refine analyses of Mariner's radio transmission time to earth in a test of general relativity—and some conclusions are already apparent. The Tharsis Mountains, for example, seem to differ from large earthly ranges, whose major bulk, buried in the earth, is less dense than the surrounding material and thus compensates for the mountains' impact on the gravity field. The Tharsis mountains appear to sit on the surface, suggesting that the Martian lithosphere may be rigid and up to 200 kilometers thick, nearly seven times that of earth. □