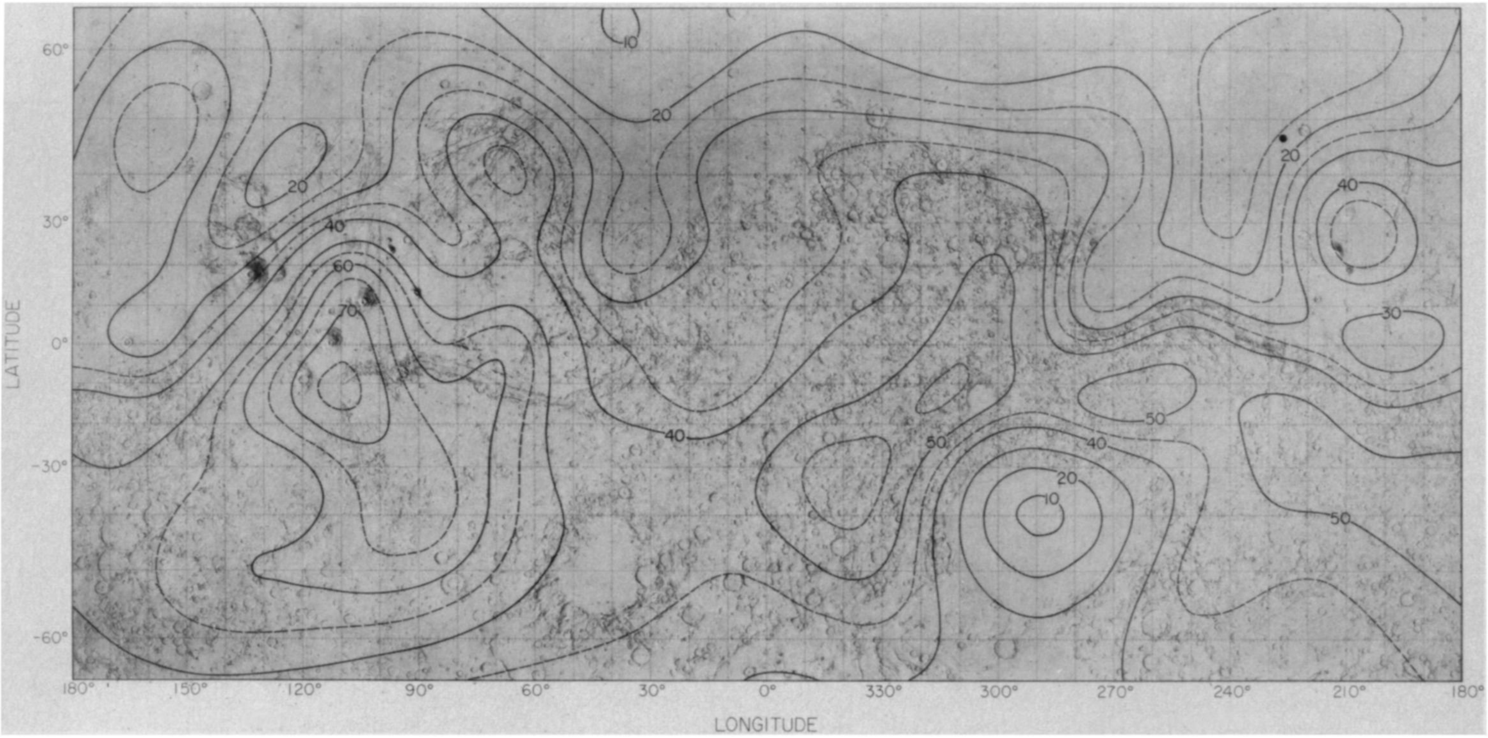
THE SKIN OF MARS

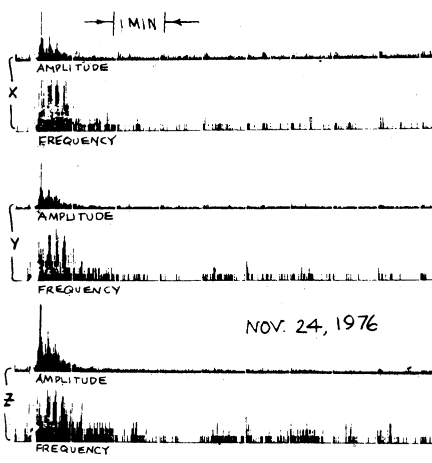
Little Mars may have a crust thicker even than the earth's according to a global map produced from a single data point

BY JONATHAN EBERHART



B. G. Bills, A. J. Ferrari

High Tharsis bulge and deep Hellas basin dominate crustal map keyed to a single measurement from Viking lander 2 (dot, upper right).



Data: D. L. Anderson

Marsquake? The one data point.

The numerous spacecraft that have investigated the planet Mars have contributed to an increasingly fascinating portrait of the ruddy world's surface and atmosphere. Each new element, however, makes researchers more hungry for insights into the *inner* Mars: Is a thick, wet, primordial atmosphere trapped beneath the visible terrain? Does Mars still creak from the stresses of a molten heart? Could the huge Tharsis bulge, site of some of the mightiest volcanoes in the solar system, recede and tilt the planet back into a more temperate climate? And how different is Mars from the earth, its moon and the rest of the "terrestrial" planets?

If there can be said to be a tragedy about the remarkably successful Viking mission, it is that one of its two seismometers, carried to the surface by the complex Viking landing craft, has never come unstuck from the locked position in which it made the 10-month trip from earth. The seismometers are the most direct keys ever provided to the planet's interior, listening and feeling for rumblings that can tell much about the structure and composition of the depths of the world beneath them. For most such studies, however, at least two are needed to plot the directions and distances of possible seismic events. Viking has only one.

Yet the potential of such probing is already proving itself. Only two possible major tremors have been detected by the surviving seismometer (the one aboard lander 2 in the Plains of Utopia), and one of those has since been discounted. The remaining possible event, however, essentially a single data point, has begun the direct study of the inner Mars by providing a calibration point for a map of the thickness of the crust over the entire planet.

Basing a global map on one local measurement—the crustal thickness directly beneath lander 2—is a risky business, as the participants admit. It becomes more so in view of the possibility that the jigglings recorded last Nov. 24 do not represent a seismic event at all. An "event" recorded 20 days previously occurred at a time of day when wind was thought unlikely to be shaking the lander; the wind sensor was off at the time, but winds had not been recorded on prior days at that hour. Over subsequent months, however, says Viking seismology team member Gary Latham of the University of Texas, similar seismic traces showed up at the same time and with the wind known to be blowing.

The Nov. 24 data have not been thus discounted. Furthermore, the sole tentative data point is one more than had existed throughout the previous centuries of Mars-watching, so the resulting map would thus appear worthwhile, at least as speculation. It also seems to be a reasonable result: thickest at Tharsis, thinnest at the floor of the deep Hellas basin. And, with future seismic events an unknown quantity and future Mars missions in a similar condition, it may have to suffice for a long time.

Given all the "ifs," the crust of Mars beneath the rock-strewn plain occupied by lander 2 is about 16 kilometers thick. The number comes from measuring the elapsed times between three successive peaks in the Nov. 24 data, assuming that the first peak represents a tremor traveling directly to the lander while the subsequent ones represent a longer path in which the signal is reflected from the crust-mantle boundary.

Seismology team leader Don Anderson of the California Institute of Technology passed on the one precious data point to Bruce G. Bills and Alfred J. Ferrari of Jet Propulsion Laboratory, who would produce the map itself—with another set of assumptions. Gravity data inferred from variations in the orbit of the 1971-72 Mariner 9 spacecraft (Viking's predecessor) were used to indicate the planet's overall mass distribution. Bills and Ferrari then adopted a "reasonable" number of 0.6 grams per cubic centimeter as the difference in density between the crustal material and the heavier mantle. The size of the difference affects how steeply the underside of the crust must dip up and down to help account for the gravity variations. This, in turn, was corrected for the visible ups and downs of the surface topography.

All these factors add up to emerge from a computer as variations around some mean crustal thickness. Then it's just a matter of trying different mean thicknesses to find one that yields a 16-kilometer thickness at the lander 2 site. According to the resulting map, the mean thickness of the Martian crust is 40 kilometers, rising to 77 km at the highest point on Tharsis and thinning out to only 8 km where some huge, ancient meteorite punched the hole that is Hellas basin.

One ready conclusion from the map is that, compared with the earth, the Martian crust is thick indeed. Earth's average crustal thickness, says Anderson, is about 33 km, and it covers a planet with nearly twice the radius of Mars. Earth's crust, then, amounts to about 0.5 percent of its radius, against 1.2 percent for the same comparison on Mars—and 4 percent for earth's moon, a still smaller body.

Mars, says Anderson, thus seems to be considerably more differentiated than the earth. There are several possible reasons, he suggests: Perhaps Mars formed with a greater percentage of lightweight materials than did the earth. Or, Mars may have had more water when it formed (consistent with its greater distance from the sun), which would have lowered the melting point of "crustal-type materials." A third source of greater differentiation could have been a greater concentration of heat-producing radioactive elements. This last case seems unlikely, Anderson says, at least for the heavy radionuclides that would have contributed the most heat, although Viking reported a high ratio of argon 40 to argon 39 suggestive of considerable outgassing of the decay products of potassium 40.

Furthermore, recent studies have concluded that the moon, with the relatively thickest crust of all three bodies, has a smaller excess of radionuclides relative to the earth than had previously been supposed. Perhaps the thin-skinned earth, rather than the crustier moon and Mars, is the anomaly. Earth is closer to the sun than is Mars, of course, which could account for some of the lack of lightweight, low-melting-point crustal material, but then what about the moon? Is this support for the theory that the moon was formed farther out in the solar system?

Even as a first start, the Martian crustal map seems to have a place in comparative planetology. For correlations with individual, localized features, however, it may be less useful, says Ferrari; this is particularly true for the northern hemisphere, since Mariner 9, which provided the gravity data, was closest to the planet in the south.

Still, it is tempting to look. The only other place on the map, for example, where the crust seems to be almost as thin as in the floor of Hellas is a spot centered at about 63°N and 38°W. The Viking orbiters have shown that spot to be relatively undistinguished (at least there are no gigantic basins), but it does exhibit the lowest general topography of any point at that latitude. Broadly speaking, in fact, that whole latitude seems to exhibit some of the thinnest crust on Mars. Perhaps the map is showing that a spinning planet, besides becoming fatter overall near the equator, concentrates its crustal material at lower latitudes after differentiation has taken place.

The map is only a first step. It will be improved with the addition of Viking's gravity data to make up for Mariner 9's southern inclination, and additional seismometers from some future mission could make a major difference. But it sure gets a lot of mileage out of one data point. □

.... Monkeys

There are other apparent parallels between monkey and human behavior. In separating monkeys from their mothers, Harlow demonstrated that the infant monkeys react in ways very similar to those of human children. In both cases, vocalization or crying increases and depression sets in. Other researchers have shown that in the absence of other relationships, including one with the mother, infant monkeys can develop strong attachments for adult males, who become sort of a "big brother" to them.

There has been considerable debate over to what degree animal findings can be applied to humans (SN: 4/27/74, p. 274). Suomi, for one, believes that "in terms of patterns and developmental trends and how different social relationships form," there are "analogies with humans."

Many of his own results over the last two years correlate with similar studies performed with human infants living either in group situations or with their parents, Suomi says. A sign of the growing closeness of human and primate research was a recent meeting, hosted by Suomi and the Wisconsin lab, where researchers from both areas met to discuss standardizing testing mechanisms in the two disciplines. "The analogies and similarities," says Suomi, "are there." □