Viking: Quake Questions and Relativity Refinements

After months of work at their exhaustive pace, Viking scientists had been looking forward to the communications gray-out of solar conjunction as a time when they could relax, study their reams of accumulated Martian data and perhaps even squeeze in a little vacation. Instruments aboard the two orbiters and two landers were either shut off or set to operating at greatly reduced levels for what would presumably be an uneventful month. "But," says one Viking official at Jet Propulsion Laboratory in Pasadena, "you turn your back for a minute, and *wham*!"

Just what "wham" is not certain. It may have been a gust of wind, or an instrumental effect—or the first "Marsquake" ever detected, a stunningly important sign of activity in an ancient world and a forceful message that the Red Planet may be far more exciting than even Viking's fascinated scientists have dared to hope.

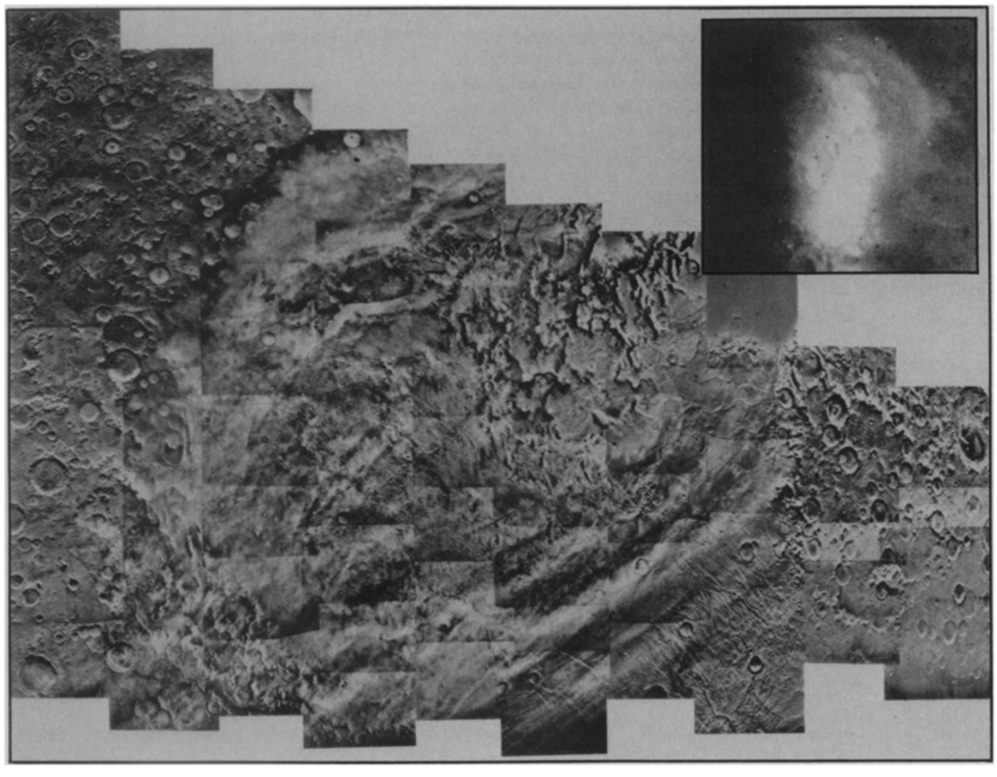
Unfortunately, the Viking landers were in poor shape to prove the point. The seismometer aboard lander 1 has not worked since the spacecraft landed in the Chryse basin last July 20. Its twin on lander 2, sitting in a rock-strewn field in the vast Plains of Utopia, has functioned even better than expected (thanks to the low Martian "background noise"), but for the period surrounding solar conjunction it was commanded to take fewer readings so that its output would not overfill the tape recorder that had to store everybody's data for the whole month.

More precisely, according to chief Viking seismologist Donald Anderson of the California Institute of Technology, it was in a "background-monitoring mode," collecting only 4 readings per minute compared to the more than 60 per minute prior to the conjunction period. The instrument was set to switch automatically to a higher data rate in case a major seismic event came along, but again the threshhold for the switchover was set high to prevent wind gusts that might shake the spacecraft from drowning the tape recorder in irrelevant data.

The "wham" showed up anyway. It appeared on Nov. 6, lander 2's 60th Martian day on the surface, at about 7:30 p.m. in what the Viking team calls LLT, or Local Lander Time. Months of measurements by the lander's meteorological, as well as seismological, instruments had clearly established that the time of day when the event occurred was one when the dry Martian winds were extremely quiet. Although the weather instruments, too, were taking readings only periodically during conjunction, data from an hour before and just after the event confirmed the low winds. Nor were there any on-board lander activities such as movements by the sampling arm or rotations of the turntables in the biology instruments to shake the spacecraft. Mars does creak a little as it heats up and cools down each day, but on a much smaller scale. "It was," says Anderson, "an extremely unusual event."

If it was in fact a Marsquake, it was a lulu. Anderson's team had already been understandably unhappy about the nonworking seismometer aboard lander 1, and that was back when no one even knew whether there were any seisms to meter. Now there is the frustration of having an apparent seism—and a big one—with no way to triangulate its location. However, Anderson says, if it was a quake, its epicenter seems to have been about 7,000 kilometers away, ringing Viking's bell with a shock of magnitude 6 or better, making it an event that the California seismologist refers to from experience as "San Fernando-sized."

The tremor registered an amplitude increase on all three axes of the seismometer, and it followed a typically quakelike pattern: an initial rise, representing the oncoming pressure wave, then a longer, more gradual rise analogous to the shear wave, and finally a tapering off like the classic Rayleigh wave-train. The data from the rest of the conjunction period, though admittedly at a less-than-ideal sampling rate, seem to show no detectable aftershocks. If it was a Marsquake, however, says Anderson, there should be more, and he estimates that it will take



Photos: NASA/Viking 1

Spectacular view of Hellas basin, largest impact feature on Mars, is the first photo to clearly show the basin floor, usually obscured by glaring frost or ice (inset) or by dust as it was seen by Mariner 9. In this photo, taken by Viking orbiter 1 shortly before conjunction, traces of frost still create striking albedo variations in the northwest part of the basin, but finely detailed flow features show clearly to the southeast. The fanlike patterns of some of these channels resemble periglacial "debris fans" on earth and may have been caused by ancient glacial deposits which eased and abetted the movement of solid surface material.

at least a year to get a clear picture of the seismic activity level of Mars, which is expected to be somewhat greater than the moon's, but considerably less than that of earth.

If the event turns out indeed to be the first major tremor ever detected on another world, it will have been a major result indeed, but Anderson's team seems to have been beset with frustrations in the discovery. Not only did the lack of lander 1's seismometer prevent pinpointing the site of the event, but the event occurred on the very first day in which the working instrument was set at its low data rate for solar conjunction. In other words, if it had happened less than 24 hours earlier, there would be a 15-times-clearer portrait of a . . . Marsquake?

Not all of Viking's scientific teams were suffering from low data rates and delays for tape-recorded data, however. The radio science group was working at its peak (SN: 11/20/76, p. 325), in fact, studying phenomena ranging from the gravitational field of Mars to the outer layers of the sun. One of the team's major projects, oddly enough, was perhaps less directly connected with Viking's other interdependent investigations than was any other aspect of the mission: a major test of the theory of general relativity.

The test used no special scientific instruments aboard the spacecraft at all, merely the radio signals between Viking and earth. General relativity theory predicts that a radio beam passing through a strong gravitational field will be slowed and deflected in toward the center of the field. Solar conjunction, with the sun between Mars and earth, offered a natural opportunity to test the theory as the signal path approached, grazed and receded from the sun.

The undertaking was, to put it mildly, painstaking, involving measurement of times as short as a few millionths of a second and distance errors as small as 5 feet in more than 200 million miles. The landers, because they were stationary on the Martian surface, were used to determine the precise positions of earth and Mars in their orbits, while the orbiters, equipped with two transmitting frequencies, were used to separate out the smaller but significant deflection caused by the physical passage of the beam through the sun's corona. The National Aeronautics and Space Administration's huge, 85-meter tracking antennas had to be used two at a time for the experiment so that the coronal and orbital effects could be measured simultaneously.

The maximum time delay attributable to relativistic effects was predicted to be 200 microseconds, according to Irwin I. Shapiro of the Massachusetts Institute of Technology, building up from about 50 microseconds when the landers first touched down last summer and tapering back to a similar level by about this coming April. The peak measurements were made when the earth-Mars line was only about 1° away from the sun, since with the sun right in the way its "noise" simply deluged the radio signals and made them virtually undetectable.

So far, the radio team has refined the measurement uncertainties down to about 0.5 percent, which, says Shapiro, is already at least twice as precise as past experiments, and he expects that it will be possible to shrink them down to 0.1 percent or better. The preliminary results, he says, indicate that "general relativity seems to be holding up."

Yet there's irony here, too. If Einstein's theory is true, he says, the Viking test will not be able to fully resolve the choice between general relativity and the theories that compete with it, since the other theories have been "contrived" with "fudge factors" to agree with the effects that it explains. It is only if the refined measurements show an effect different than predicted by relativity, according to Shapiro, that it may be feasible to look toward one or another theory that may happen to diverge from general relativity in the same direction.

At stake, he points out, are a host of astrophysical subjects, ranging from whether black holes have any right to exist to whether the universe is continuously expanding or cyclically pulsing. The scope of the Viking mission to Mars, in other words, is far wider than any single planet. □

Moth mating: Role of diet challenged

A promising approach to control of pest damage is to lure insects into traps with synthetic chemicals modeled on the insects' own attractants or to use such chemicals to confuse normal mating. These strategies require knowledge of the sex attractants, called pheromones, present in small amounts in the female insects.

Two years ago, a group of entomologists proposed a novel theory linking the diet and pheromones of the oak leaf roller moth, a pest that has seriously damaged forests in the northeastern United States. Lawrence B. Hendry and co-workers at Pennsylvania State University suggested that pheromones are not manufactured by the insects, but rather that female insects store chemicals from their plant diet and later release them as attractants (SN: 11/30/74, p. 343). The researchers further speculated that insect species may be divided by diet into reproductive units. Only individuals raised on the same food, it was suggested, would be able to attract each other and mate.

Hendry based his proposal on evidence that the same chemicals were present in plants and in insect pheromones, that males were attracted by a variety of these chemicals and that the pheromones in the female moth varied with diet. These findings were recently challenged by scientists in another laboratory and now, in the Jan. 7 SCIENCE, they are challenged by two participants in the original research.

The first conflicting evidence was reported last April by James R. Miller and colleagues at the New York State Agricultural Experiment Station (SCIENCE 192:140). They found that the sex pheromone of the female oak leaf roller moth was a specific blend of chemicals, a 2:1 ratio of *trans*-11- and *cis*-11-tetradecenyl acetates. Miller's group reported that male moths responded only to that same mixture of chemicals. Finally, they observed no significant difference in the pheromones of moths raised on chestnut oak, black oak, white oak or pinto bean diets.

The recent evidence of David M. Hindenlang and Joseph K. Wichmann, coauthors with Hendry of the paper that first proposed the diet-pheromone theory, correlates better with the results of Miller than with their own previous data. Using the same basic method (combined gas chromatography and mass spectroscopy) they did a more thorough analysis of both the insect pheromones and the plant chemicals. "We did the exact same experiments and then elaborated on them to clarify the results," Hindenlang explains. "Within the same framework, we changed chromatographic conditions and used different ionization techniques."

Like Miller, they found that the chemical composition of the moth pheromone was a fixed mixture of two tetradecenyl acetates. In tests of plants Hindenlang and Wichmann found no pheromone chemicals in oak leaf, apple leaf or corn extracts. On first analysis, the extracts gave a peak in the same region as the pheromones, but further experiments showed that the compounds were entirely different.

"If any tetradecenyl acetates were present in these oak leaf extracts, they would be present on the order of one to ten parts per trillion or less," Hindenlang and Wichmann state.

Hendry, the main proponent of the diet-pheromone theory, did not coauthor the most recent paper with his colleagues. He is currently in the process of repeating his experiments separately and is not ready to give up the hypothesis.

Hindenlang and Wichmann point out that data on two other types of insects seem to be consistent with a direct effect of diet on insect communication chemicals, but their recent results on the oak leaf roller are not. They conclude, "Thus, we do not deem it appropriate to advance a hypothesis regarding a direct association between plant chemistry and insect sex pheromones. Furthermore, we retract previous reports and interpretations of data suggesting such an association." □