Mapping the topography of Mars with radar

Radar is one of the important and most accurate tools for determining the topography of nearby planets. Venus was the first planet on which such mapping studies were made (SN: 2/24/68, p. 183). A year ago Mercury was similarly studied (SN: 5/2/70, p. 436). In the last three months, taking advantage of the close approach of Mars, the 120-foot radio/radar antenna at the Massachusetts Institute of Technology's Haystack Observatory (formerly Lincoln Laboratory's) has been used to map that planet. The work was done by Gordon H. Pettengill, A. E. E. Rogers and Irwin I. Shapiro of MIT.

The surface of Venus is covered with clouds, so nothing was known of its topography before the radar investigations. Mercury is so small and near the sun that visual observation could tell very little. In contrast the surface of Mars is visible; it has been photographed in detail and it will be photographed in more detail by the Mariner 9 spacecraft, which is scheduled to go into orbit around Mars on Nov. 13.

But the radar measurements provide another dimension, Pettengill points out. "Photographs give east-west and north-south." Radar gives the vertical relief.

Some of the details the radar has found include a gorge two and a half miles deep and a crater more than a mile deep and 12 miles across. The greatest variation so far found in the surface elevation is 10 miles, about equal to what the earth's would be if the oceans were drained. The accuracy of the vertical measurements is about 100 yards, comparable to distinguishing the height of a marble 10,000 miles away. The horizontal resolution, says Pettengill, is about 0.8 of a degree of Martian longitude or 40 kilometers.

The measurements were made by comparing the delay in the return of successive pulses of the signal. The signal pulsed every minute. Meanwhile, Mars was rotating so that the subradar point, whose height was momentarily being measured, changed about one degree of Martian longitude every four minutes.

The data thus developed a profile of the Martian surface along a particular line around the globe. In a typical eight-hour day of observation, 100 to 110 degrees of Martian longitude could be observed, says Pettengill. The rotation axis of Mars is tilted with respect to its oribital plane, and changes in the aspect of this tilt as viewed from the earth permit profiles to be run at different Martian latitudes. The observations so far have been made between 14 and 18 degrees south latitude.

The swift rotation of Mars helps to make these measurements much more accurate than those of Venus. With Mars, profiles of sizable sections could be completed before orbital motion changed the planet's distance from earth enough to confuse the measurements.

Possible observation of water vapor on the moon

The presence or absence of water on the moon is central to theories of lunar origin and development. After examining returns of Apollo 11, scientists were fairly convinced that there was no water there because of the lack of hydrous minerals—those that contain OH radicals—in the samples. They theorized, therefore, that the original melt from which the rocks were formed had very little if any water. The returns from Apollo 12, 14, and 15 seemed to support this finding.

Now John W. Freeman Jr. and H. Kent Hills of Rice University in Houston have announced what they believe to be water vapor detected on the moon by the Suprathermal Ion Detector Experiment (SIDE). (There are three SIDES on the moon—at the Apollo 12 site set up in November 1969; and at Apollo 14 and 15 sites set up this year.) The SIDES have been quietly measuring "clouds" of low-energy ions during lunar day and before sunrise and sunset; ions with energies of several thousand electron-volts thought to have escaped from the earth's magnetospheric bow shock wave; and ions from man-made impacts, lunar landings and lift-offs.

The SIDE instruments have 20 channels for detecting ions ranging from 6 to 120 atomic mass units. Apollo 12 and 14 instruments had, for example, detected the venting of oxygen from both of the lunar modules.

But on March 7, the instrument saw something unusual at the 14 site—a very high flux of ions in the spectrum (channel 5) predicted for water vapor. Apollo 12's SIDE also detected the ions.

The flux of 783 counts per 1.2 seconds was much higher than anything seen before—more than a hundred times greater than that detected when the lunar module vented.

Since this finding was quite sensational, Freeman and Hills were cautious: "We are not claiming this is water vapor," Hills told SCIENCE NEWS in May. "There are other molecules in this mass range." (Channel 5 detects ions in a range from 18 to 23 mass units; water vapor is 18, neon is 20.)

Since then, however, the team has done more work calibrating the instrument. Simulations in the laboratory, says Hills, have shown that water vapor peaks in channel 5; neon, while also showing up in channel 5, tends to peak in channel 6.

Another unusual aspect of the detection was that the flux occurred at the same time that swarms of moon quakes were detected—rumblings (on earth associated with tectonic activity) that lasted from 12 to 14 hours (SN: 9/11/71, p. 167). The ion occurrence began shortly after the moon quakes began, and stopped shortly after the quakes ceased. Freeman speculates that water vapor could have come from a fissure created by the quakes. And, says Hills, the findings would not contradict the lack of water in materials found at the surface if the vapor were coming from deep within the interior.

The implications, if the observation is confirmed, are considerable. "If water vapor is coming from the moon's interior," says lunar scientists Farouk El-Baz, "this is serious. It means that there is a drastic distinction between the different phases in the lunar interior —that the interior is quite different from what we have seen on the surface." (It is not known why the crustal material sampled is depleted in volatiles and water.) There could be pockets of molten material and pockets of water beneath a thick crust, says El-Baz. This would mean that the interior composition is quite different from the crust's.

"This is all quite plausible," says Paul Gast of the Manned Spacecraft Center. "We know that volatile material wants to expand—it goes faster and faster as the pressure is released." Gast believes the vapor could be from as deep as 800 kilometers within the moon.

The Rice team is confident that they are seeing a natural event. It is unlikely says Hills, that the vapor is coming from any of the lunar modules because Apollo 12 and 14 are located some 180 kilometers apart, and yet the event was seen with the same flux at both sites. In addition, the two instruments face in opposite directions.

"This must be confirmed," emphasizes Gast. "It will make the scientists look a little harder for the evidence of water in the lunar material." □