Mariner's intriguing evidence

If water created the channels on Mars, where is it now? Under the possibility that there may be life? This is an exciting time for

by Everly Driscoll

Laminated terrain near south pole.

Mars has thrown a monkey-wrench into the way scientists study the history of the solar system.

Planetary scientists compare the atmospheres of earth, Venus and Mars and extrapolate back to the original solar nebula to try to explain how each planet evolved. But they are finding it difficult to explain what Mars has been in the past by looking at what it is now.

The photographs taken by Mariner 9 were a shock. The new photography unveiled a more earth-like planet than seen in earlier spacecraft photos (SN: 8/12/72, p. 104). There are huge volcanoes, large faults and rift valleys and channels.

The channels are the biggest enigma. There are three types, and at least two appear to be water-eroded tributaries and valleys. Some scientists don't believe it. Others, such as Paul Lowman of the Goddard Space Flight Center say the branch-like channels are "conclusive proof" of liquid water.

How to explain this evidence for liquid water on Mars has become one of the hottest issues in space science. It has stimulated all kinds of creative finagling and rethinking. If water cut the channels, where is it now? Under what conditions and when could this have happened? Is Mars a planet that is being born, atmospherically, or is it dying?

Harold Masursky calls this braided channel the "clincher" for the water argument. Only comparable terrestrial phenomena are water channels with sandbar islands.

Mars' atmosphere, like that of Venus, is primarily carbon dioxide with traces of water vapor and ozone that vary regionally and seasonally. But the surface pressures and temperatures of Mars and Venus are vastly different. Pressure on Venus is now about 90 times earth's; on Mars it is only .006 of earth's. Venus is far hotter than either earth or Mars.

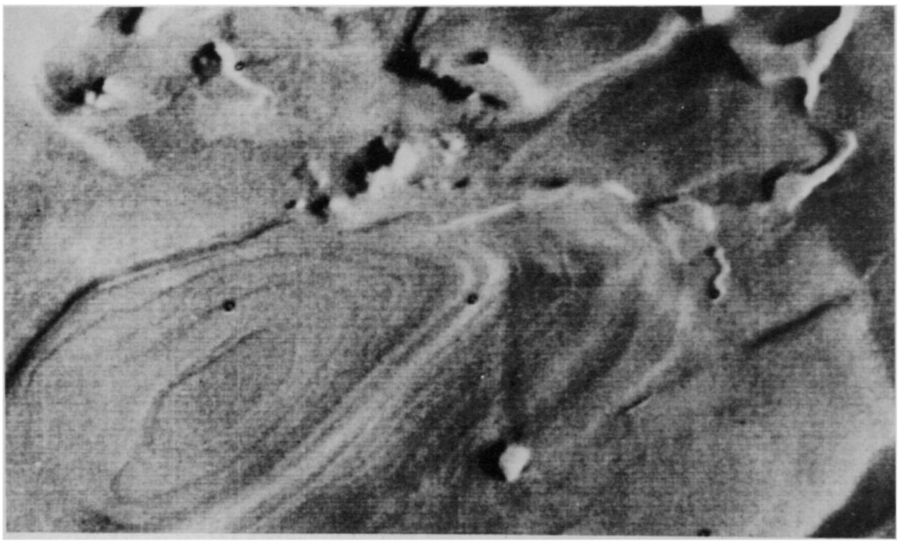
NASA's S. I. Rasool has developed a theory to account for these evolutionary differences. He believes they are based on the planets' distances from the sun. Venus began too hot for liquid water, for example. Earth was just barely cool enough. For Mars the situation is complex, but probably during much of its history it has been too cold for liquid water. The present atmospheres of the three planets resulted from volcanic emanations, photochemical dissociation of water vapor, oxygen produced by photosynthesis (on earth), and so on. Rasool thinks the chain of events that led to earth's present atmosphere began only because the initial temperatures were in the neighborhood of 2

Photos: NASA/Mariner 9

Channel with upstream tributaries.

# of a formerly watery Mars

What conditions could it have happened? What does it do to for netologists studying Mars.



Laminated terrain, "like a fallen stack of poker chips," in south polar region may, some scientists think, be related to the water-channel mystery on Mars.

degrees C. "Water vapor, the major constituent of volcanic emanations was able to condense out of the atmosphere to mark the beginning of oceans. . . . The initial temperature of a planet is an extremely critical parameter in determining which evolutionary path a planetary atmosphere will follow," he says. In fact, he has calculated that had earth's temperatures been only 5 degrees C. warmer, the earth would have missed the liquid phase of water at its surface.

Liquid water seems to be the key. To have liquid water the temperature must be above freezing, and the surface pressure must be sufficient to keep the water from evaporating. Venus began too hot for liquid water. In fact, according to a widely accepted model by John Lewis of the Massachusetts Institute of Technology for the chemical compositions of the terrestrial planets as they accreted from the solar nebula (SN: 4/8/72, p. 233), Venus began with very little water. What was there, then vaporized. The hydrogen escaped and the oxygen probably combined with crustal material. Carbon dioxide is too heavy to escape.

What happened on Mars? The initial temperatures, if less than zero degrees C., caused the volcanic steam to freeze, and only carbon dioxide accumulated. From the photographic evidence, Mars has had considerable volcanism, so geologists believe that there is a tremendous reservoir of both carbon dioxide and water on Mars. The carbon dioxide not in the atmosphere is probably trapped through chemical reaction in the crust; the water is frozen. In Lewis' model, Mars actually accreted with six times more water, gram for gram, than earth.

Before Mariner 9, there was some question about whether there was *surface* water in any form on Mars. The polar caps appeared (from Mariners 6 and 7) to be carbon dioxide ice. Now scientists know that under that dry ice there is some water ice. Then the dust cleared and the scientists saw the channels. How could these have been eroded by torrents of liquid water? Some investigators, such as Bruce Murray of the California Institute of Technology, think it would require miracles—at least one, maybe two.

Another intriguing feature of Mars that some feel may be tied up in the channel mystery are the laminated terrains of the north and south polar regions. In Murray's words, they look like a fallen stack of poker chips. He and three of his students, Michael C. Malin, William Ward and Sze Yeung, have done some calculations to explain these laminations, and other scientists say his explanation might solve the water problem as well.

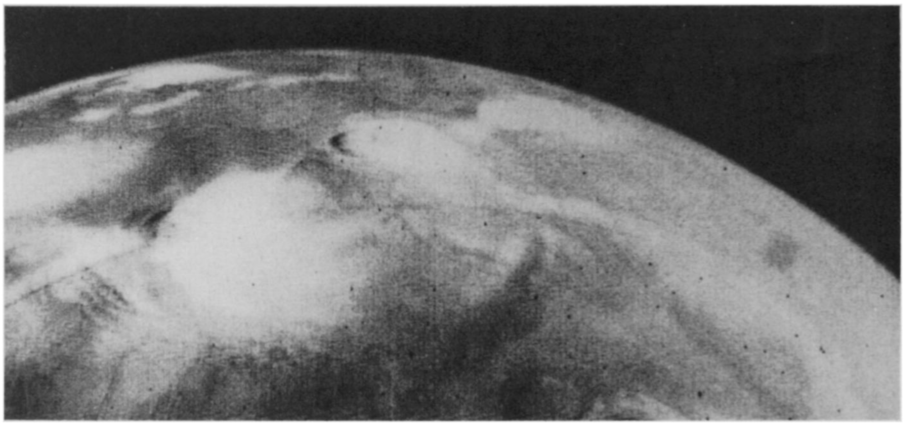
The laminations are thin layers collected in units of 20 or 30 to make up plates of half a kilometer or more in thickness. Murray and students suggest the rotational axis of the planet has been displaced over the past tens of millions of years (maybe as the result of internal convection). The shifting of the spin axis has allowed the plates to form concentrically around the poles. He thinks these may be associated with periodic alternations in the climate of Mars.

Long-period variations (in cycles of 50,000 years, 90,000 years and 2 million years) in Mars' orbit caused by perturbations of other planets shift the orbit from nearly circular (.004) to highly elliptical (.141). The current value is .09. When the orbit is elliptical, Mars comes closer to the sun. This change in orbit would lead to changes in the average amount of solar energy reaching the poles and changes in the peak energy reaching the planet when it is closest to the sun.

Could this change in temperature create liquid water? Murray thinks not. It would evaporate, given the current pressures. But there is some speculation now that if volcanic activity had pumped enough water vapor into the Martian atmosphere, the pressure could build up, allowing liquid water.

It may *not* be necessary to change the orbit to get localized, momentary patches of liquid water on Mars now. C. B. Farmer, Frazier Fanale and others at the Jet Propulsion Laboratory are working on this possibility. The most important thing is liquid water near the surface. "This is difficult to image," admits Fanale. But, he adds, "it is conceivable that in the regions where brightening occurs [from afternoon clouds of water ice that form over areas such as Nix Olympica], a portion of the water desorbed from the soil surface may be trapped in the soil pores and may condense as liquid at 273 degrees K. [zero degrees C.]." He thinks the more likely scenario is the melting of subsurface ice rather than sublimation at the base of permafrost. This could result from igneous activity.

Farmer is working out detailed examinations of the rates of water evaporation versus rate of melting on Mars. He is using earth-based measurements of water vapor in the atmosphere during the northern summer at temperate latitudes. He has seen as much as 40 to 50 precipitable microns. (This means that if all the water in a vertical



Clouds above major Martian volcanoes are made up of crystals of water ice.

column extending all the way to the top of the atmosphere were condensed, it would form a layer on the surface 40 to 50 microns deep.) The atmosphere during the Martian night cools off and can't hold that much water. The water becomes frost.

In areas where the rate of heating is sufficient to exceed the heat needed to evaporate, the excess heat could be used to melt snow under the surface layers. If this happens at low elevations, where the air pressure is higher, some of the resulting water could stay temporarily in the liquid phase, instead of evaporating. This liquid phase would be transitory. But if the water runs into the surface soil, it could stay for several hours, according to Farmer's calculations. Trapped water beneath the surface may even stay for years in the warmer parts.

Rudolph Hanel of Goddard says there are areas on Mars in which the surface pressure exceeds 6.1 millibars. "These are of biological interest because under temperature conditions which frequently occur on Mars, liquid water can exist. . . ." Further he says that preliminary topographic mapping between latitudes 65 degrees south and 20 degrees north indicate that "the surface pressure in the southern summer exceeds 6.1 millibars in fairly large areas of Argyre, western Margaritifer Sinus, Isidis Regio and Hellas."

What does the possibility of liquid water—at any time on Mars—do to the probability that the Viking landers in 1976 might find life? Bradford Smith of New Mexico State University is cautious: "Whatever probability we assigned to life on Mars five years ago is . . . much higher now." Arthur Lane of JPL raises another problem in regard to life as we know it: There is very little nitrogen on Mars. "One of the things we do require for amino-acid formation in the kind of molecules we know for life is carbon-nitrogen bond systems. There can be a very difficult problem there trying to get over that hurdle, at least now."

The fact there is as much as 50 precipitable microns of water on Mars (about the thickness of a sheet of onion skin paper) is exciting. "That's not much for a whale, but to a bacterium, that's an ocean," says Gerald Soffen, project scientist for Viking at Langley Research Center. Wolf Vishniac of Rochester University is a biologist on the Viking team. He and other biologists are now doing calculations on exactly how much water is needed for life. How thin a layer is thick enough? Vishniac spent two months in the Antarctic looking for and finding bacteria that were nowhere near water. Where the ice contacts the soil, he found teems of bacteria in only a few layers of water molecules. He points out that bacteria can exist in temperatures below freezing, because even then a portion of the ice is liquid.

If there is water, where is the best place to find these patches, if they exist? NASA is awaiting the results of numerous investigations into these questions before it decides where to land the Viking spacecraft. Originally a decision was due in December (SN: 11/4/72, p. 300). NASA decided more study was needed. Then last month, NASA representatives went to Moscow to confer with Soviet scientists on their radar results from the Mars 2 and 3 orbiters.

At first the site selection team was just looking at the equatorial regions. Then in December, as a result of Mariner 9, NASA reexamined its potential for landing in polar regions. It hopes to have a decision in April.

Some members of the team would like to land Viking at the poles where they are sure there is water. But water there would be frozen, so other members point to the equator. The temperatures there are conducive to life, but some feel that the equator may not be the best place to find water. "We are looking for that magic place," says one Viking team member—"that cross-over place where water might result from ice." □