PERSPECTIVES: PLANETARY SCIENCE

Fountains of Youth

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Where there is water, life may be or have been. This is why Mars Global Surveyor (MGS), the flagship of NASA's current flotilla of spacecraft destined for Mars, has been acquiring volumes of data pertinent to the search for water. But, much as it was for the early pioneers who settled the American West, finding water on Mars involves both savvy and serendipity. On page 2330 of this issue (*1*), Malin and Edgett report on the surprising discovery of geologically young gullies and debris fans emanating from beneath strata exposed along steep martian scarps. Their findings indicate that Mars, although extremely cold and arid at present, has very recently, probably within the last few million years, produced sizable discharges of spring water. Strangely, these features occur in the higher, more frigid latitudes.

Because of its many geologic similarities to Earth, Mars has captured the attention of terrestrial observers for centuries. Notions of a habitable climate on the Red Planet first arose when prominent astronomers including William Herschel, Giovanni Schiaparelli, and Percival Lowell interpreted the bright polar regions and the perceived dark wispy lines as polar ice caps and canals. With the advent of spacecraft exploration, however, Mars came to be regarded as a cold, arid world, where surface water will either freeze rapidly or boil away. Most evidence from the Viking and Mars Pathfinder missions indicative of running and standing water on the planet has generally been attributed to bygone eras more than a billion years ago (*2*).

In their search for more recent landforms indicative of fluid discharge and runoff, Malin and Edgett have examined tens of thousands of high-resolution images obtained by the Mars Orbiter Camera (MOC). Thus far, they have located more than a hundred such sites—cliffs and scarps that bear alcoves, gullies, and debris aprons. On Earth, alcoves commonly form in cliffs above horizontal zones of seepage along rock bedding planes and fractures. Aprons or fans develop where surface runoff deposits debris downslope, and gullies form where flows erode into the debris.

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Finding such features on Mars would not be unexpected if these features were associated with the ancient valley networks, produced when the crust and climate may have been warmer (*3*), or on the flanks of volcanoes that could have circulated hydrothermal water or been affected by local, wet microclimates (*4*).

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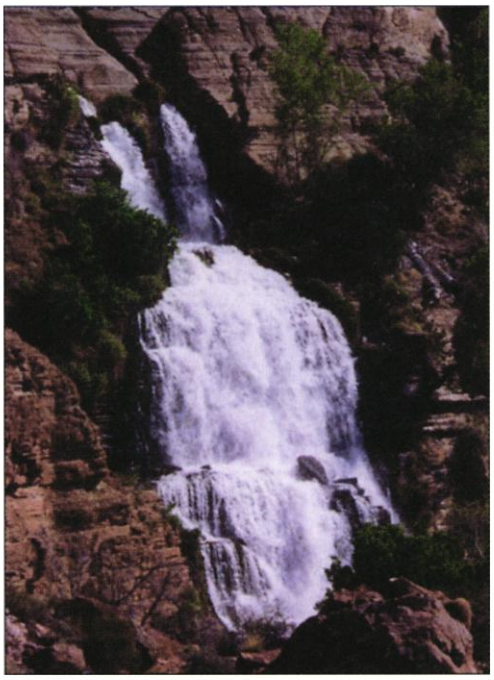
Instead, the gullies are restricted to the walls of high-latitude craters, channels, grabens, and south polar pits. Malin and Edgett observe that the debris fans are among the youngest geologic features on the planet. The lack of young seepage examples in equatorial regions may be explained by long-term desiccation of the upper crust at these latitudes (*5*). The discovery of these discharge features dispels the notion that the high latitudes of Mars are deeply frozen. This leads to new enigmas. For example, how can liquid water exist at such shallow depths (at less than 1000 meters) at high latitudes, and why have no older seepage features been found?



Recent gushers like this on Mars? Thunder Spring emerges from twin caves in the Muav limestone some 1100 meters below the North Rim of the Grand Canyon, Arizona. Similar discharges from beneath strata may explain youthful drainage channels and debris aprons along cliff walls on Mars (*1*).

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The groundwater depths implied by the seepage features indicate a Mars with exotic saline groundwater solutions and with higher heat flow, lower thermal conductivity, and/or higher mean surface temperatures than generally assumed (*6*). Alternatively, CO_2, with a freezing point of 217 kelvin, may have been the discharged volatile; CO_2 would flash from liquid to gas as it decompressed below 510 kilopascals, possibly resulting in gas-supported granular flow.

In any case, if additional analysis confirms Malin and Edgett's conclusion that the seepage features are all very young, then some very unusual event occurred in the recent past on Mars. We should reexamine the commonly held view that only during the first billion years of the planet's history or in association with geothermal events was Mars warm enough to produce shallow groundwater discharges. Perhaps large, chaotic variations in Mars' obliquity led to substantial temporary changes in the planet's climate that initiated spring discharges at high latitudes. More than 5 million years ago, obliquity may have episodically exceeded 45° (*7*), thereby enhancing solar insolation of the polar regions and poleward-facing scarps. Such warming may have melted near-surface ice, allowing the release of fluids entrapped within permeable zones. Older, shallow discharges may also have occurred within preexisting valleys or elsewhere and may be obscured or just not recognized yet.

Additional insights into the seepage features may be gained from the Mars Orbiter Laser Altimeter, which can provide topographic data (*8*), and the Thermal Emission Spectrometer (TES) onboard MGS. The outcrop areas approach the 3-kilometer spatial resolution of TES, which may be able to provide spectral data to infer compositional and thermophysical properties of the debris fans (*9*). Future lander missions could provide in situ observations, if they could be directed to higher latitudes, steeper terrains, and precise landing sites. Low-flying airplanes or robotic balloons could also obtain close-up observations. Such missions may be required to effectively test for extant life and to optimally locate a human outpost on this Earth-like yet still mysterious planet.

References

1. M. C. Malin and K. S. Edgett, *Science* **288**, 2330 (2000).
2. M. P. Golombek, *Science* **283**, 1470 (1999).
3. S. W. Squyres and J. F. Kasting, *Science* **265**, 744 (1994).
4. V. C. Gulick and V. R. Baker, *J. Geophys. Res.* **95**, 14325 (1990).
5. F. P. Fanale, J. R. Salvail, A. P. Zent, S. E. Postawko, *Icarus* **67**, 1 (1986).
6. S. M. Clifford, *J. Geophys. Res.* **98**, 10973 (1993).
7. J. Touma and J. Wisdom, *Science* **259**, 1294 (1993).
8. D. E. Smith *et al.*, *Science* **284**, 1495 (1999).
9. P. R. Christensen *et al.*, *Science* **279**, 1692 (1998).