PLANETARY SCIENCE

A Smashing Source of Early Martian Water?

The Red Planet is bitterly cold, bone dry—at least at the surface—and nearly airless. And it seems to have been that inhospitable for at least several billion years. But planetary scientists are deeply divided over whether the very earliest Mars was more conducive to the origin of life. "Geologists say there was all this water, overflowing lakes, and massive erosion," says planetary geologist Michael Carr of the U.S. Geological Survey in Menlo Park, California. But climate modelers can't explain why Mars would have been any warmer in its earliest days than it is today. Now, on page 1977, a group of physics-inclined planetary scientists proposes a solution to that conundrum: giant asteroid impacts.

The great impacts that pockmarked early Mars and their ejecta would have thawed the frozen planet's subsurface water and led to "episodes of scalding rains followed by flash floods," the scientists write. The group has a "perfectly plausible way of making rain on Mars," says planetary physicist Kevin Zahnle of NASA's Ames Research Center in Moffett Field, California, a co-author of the paper. "The details have to be worked out, but fundamentally, this is the answer." That stance gets some support from planetary scientists, but most researchers particularly intimate with the geologic record of earliest Mars disagree. "It's a valiant effort," says Carr, but "I'm skeptical that it really does much to explain what we're seeing."

Long dry. Four billion years ago on a wet Mars, water drained from craters down long channels.

This early Mars mystery cropped up when, 30 years ago, planetary geologists saw their first signs that water had run free on the surface of early Mars. Branching channels on the ancient, heavily cratered highlands looked for all the world like river valleys. Large crater rims were worn down as if swept by persistent rains. And, more recently, geologists have recognized that great craters appear to have been filled to overflowing by rain on early Mars. "The amount of erosion is huge," says Carr. On the other hand, climate modelers can't stuff enough greenhouse gases into a martian atmosphere to compensate for the chilly faintness of the sun 4 billion years ago.

In making the case for impacts, atmospheric scientists Teresa Segura and Owen Toon of the University of Colorado, Boulder, along with Anthony Colaprete and Zahnle of Ames, point to the 25 largest martian impact craters. Ranging from 600 to 4000 kilometers in diameter, the craters formed after the planet's formation 4.5 billion years ago and before about 3.8 billion years ago. For comparison, the Chicxulub impact that wiped out the dinosaurs formed a 170-kilometer crater. Even the small end of the range of martian impactors considered in the new paper—a 100-kilometer object—delivered about 4×10^{26} joules of energy to the planet, the equivalent of 100 to 1000 dinosaur killers, says Zahnle.

With that much energy dumped on Mars, things got hot in a hurry. When one of those "small-end" impactors hit, it threw out enough hot rock to cover the planet to an average depth of 7 meters, the group calculates. When the rock vaporized by the impact eventually cooled and condensed, a 1600-K "rock rain" fell to cover the surface globally to 2 meters' depth. Within a few weeks, global surface temperatures reached 800 K. Now water everywhere was vaporized or melting: the water in the asteroid, the crustal water where the asteroid hit, the water in the polar caps, and, most novel in this study, the water frozen just beneath the preimpact surface (*Science*, 14 June, p. 1962) that is heated by all that hot ejecta. Parts of the subsurface would have stayed above freezing for at least a year in the case of a 100-kilometer impactor, the group calculates, for more than a century after a 250-kilometer impactor hit, and for millennia for the largest impacts.

All that thawed water would have made for plenty of erosion, the group says. A 100-kilometer impactor would have triggered 2 meters of rain over the entire planet within a few years and melted 3 meters' worth of ice. A single 250-kilometer impactor might have freed up 50 meters of water. One such impact would be enough, they calculate, to erode the mysterious valley networks. And at least 10 such objects hit Mars before the planets swept up the last of the debris from the solar system's formation.

Planetary scientists have a range of reactions to this picture of a cold, dry early Mars punctuated by episodes of sizzling rain every 100 million years or so. "The idea is well founded," says planetary scientist Stephen Clifford of the Lunar and Planetary Institute in Houston, Texas, who specializes in martian hydrology. "Ultimately, the geologists are going to have to come around."

Some Mars geologists don't think they will have to do so. Ross Irwin of the Smithsonian Institution's National Air and Space Museum in Washington, D.C., allows that impacts might have contributed to some of the earliest erosion, when the biggest asteroids were hitting, but later valley formation and the flooding of large craters seem to have required far more water than impacts could have supplied. Carr agrees that "the valleys are only part of the problem. The amount of erosion is enormous. You're talking kilometers of water," not the 50 meters from an impact.

To win any more supporters, Segura and her colleagues need to develop a better idea of the cumulative effect of both large and smaller craters over time, researchers say. But James Kasting of Pennsylvania State University, University Park, who has been struggling with the early Mars climate problem for 20 years, is not hopeful: "I'm pessimistic that any of us is going to solve it until we get some geologists up there."

–RICHARD A. KERR

PLANETARY SCIENCE

... And an Icy Patch at Mars's South Pole

Space scientists have discovered a new hiding place for water on Mars. In a paper published online by *Science* this week (www.sciencemag.org/cgi/content/abstract/1080497), three geologists report that they have found a kilometer-wide patch of water ice at the edge of the southern polar cap. The orbiting Mars Odyssey spacecraft first glimpsed the water ice in February, exposed when an upper layer of carbon dioxide ice ("dry ice") evaporated in the –20°C heat of the martian summer. This discovery might literally be the tip of an iceberg: Some Mars scientists believe that the entire southern polar cap could be water ice, covered by a thin layer of dry ice.

When Mars Odyssey began photographing the martian surface, says Phillip Christensen of Arizona State University, Tempe, "this region was one of the first pictures we took." What caught scientists' attention was a relatively flat piece of land that was colder than the adjacent exposed soil. More-

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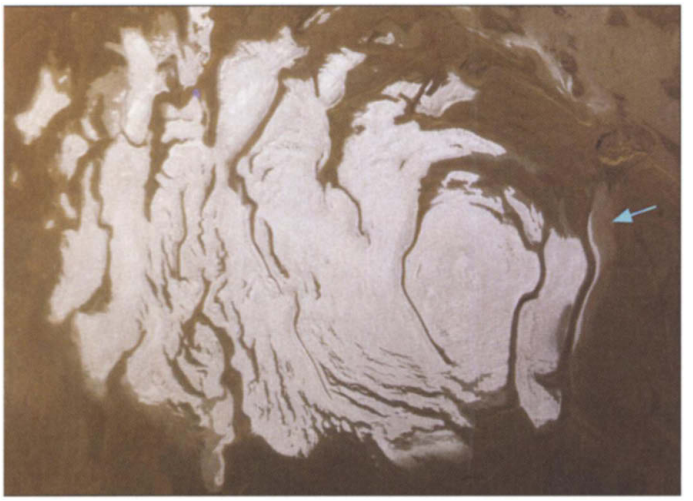

Cold shoulder. Region of water ice (arrow) flanking a vast sheet of frozen CO_2, photographed by the Mars Global Surveyor, may be typical of the fringes of Mars's southern ice cap.

detailed measurements made with the spacecraft's infrared camera revealed that the tundralike plain absorbed more heat than did the surrounding terrain during the day and radiated more heat at night. That high "thermal inertia" strongly suggested that the surface was pure water ice.

Christensen's team, which included Timothy Titus and Hugh Kieffer of the U.S. Geological Survey (USGS) in Flagstaff, Arizona, also examined old visible-light photographs of the area taken by NASA's Viking orbiter mission in the 1970s. Sure enough, the photos showed sharp delineations between bright dry ice, medium-bright water ice, and dark rock, in exactly the same places where their infrared camera had seen them. The icy plain, the researchers concluded, is a regular feature that has reappeared every martian summer for at least 25 years. Viking saw many similar medium-brightness patches around the edges of the southern ice cap, so seasonal plains of water ice might be fairly common. This suggests that the permanent layer of carbon dioxide ice might be relatively thin—perhaps only meters thick.

Other researchers say the find is like a Christmas present you have asked for: not a big surprise but good news nevertheless. "It's important to me because I predicted it," says David Paige, a planetary scientist at the University of California, Los Angeles. Several years ago, he and two other scientists studying data from the 1971 Mariner 9 mission found that the spectrum of light reflected from the south pole did not match that of dry ice alone. They speculated that the other ingredient was water ice, but their instruments could not pinpoint its location.

If the ice deposits are indeed accessible from the surface, they might someday provide a record of Mars's climatic history, just as glaciers do on Earth. "In many ways, Mars should be a simpler system than Earth for understanding climate change," says Ken Herkenhoff of USGS. "There are no oceans on Mars, and no biological community that we know of." Thus, Mars could serve as a laboratory for understanding the effects of orbital mechanics and of the sun's variations on climate.

But that understanding will come only if NASA sends a mission to the polar regions of Mars, to replace the Polar Lander that failed to reach its destination in 1999. The inaugural Mars Scout mission, to be launched in 2007, might provide an opportunity. Two of the 10 finalists for this mission, including Paige's "Artemis" proposal, involve polar landings. (The winning proposal was expected to be announced on 5 December.) "I see a groundswell of interest in going to the poles," Paige says. "The poles are where a lot of the action on Mars is." –DANA MACKENZIE

Dana Mackenzie is a writer in Santa Cruz, California.

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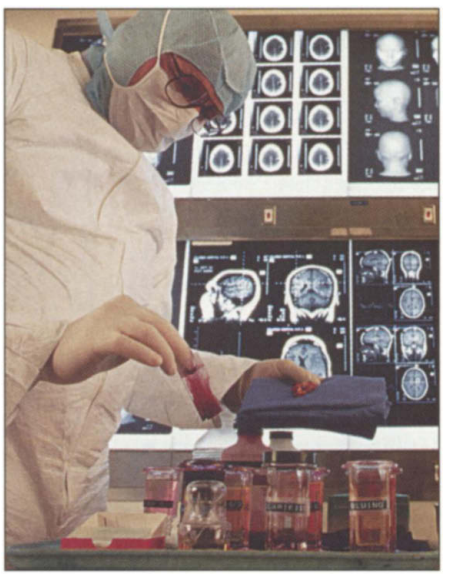
MEDICAL RESEARCH

U.K. Researchers Hope For Clarity in Tissue Use

CAMBRIDGE, U.K.—British medical researchers are facing major changes in the rules governing the scientific use of human tissues, the result of a series of scandals in the 1990s. Earlier this year, the U.K. government said it was considering drafting a law to prevent misuse of tissues and asked for



Consent required. Slices of tumors are stored in wax before disposal.

ScienceScope

Diverse Views Attempts to create a more diverse scientific work force will be undermined if the Supreme Court prohibits U.S. universities from using race as a criterion for admission, according to the head of the country's leading consortium of research universities. The thorny issue is back in the news this week after the high court agreed to hear two cases involving admissions practices at the University of Michigan.

Nils Hasselmo, president of the 62-member Association of American Universities (AAU), says that affirmative action "has been an effective means of achieving academic diversity," and that it is especially important "at the most selective end of the spectrum." He expects AAU to join other scientific and educational organizations in urging the court to uphold race-based admissions efforts.

But opponents say that several states have come up with alternative ways to increase diversity on campus without discriminating against Caucasian students, two of whom filed lawsuits seeking to overturn Michigan's policies.

Stressed Out The average corporate executive is more relaxed than an academic at the Massachusetts Institute of Technology (MIT), according to a university-sponsored survey released this week. More than 60% of MIT's nearly 1000 professors say that they are emotionally and physically drained at the end of the workday—and 78% say they can't get everything done no matter how hard they try, according to the study, which took the pulse of faculty stress. By comparison, just half of corporate executives feel the same way, according to the independent company that analyzed the data.

The study also found that two-thirds of MIT faculty are not happy with their job's pace and pressure. Less than half worked 60 hours a week or more in 1989; now two-thirds do. And more than half say the pressure has a negative effect on family life and professional relationships. Women and untenured professors report feeling more stressed and overworked than their tenured male counterparts do.

The alarming statistics have prompted MIT administrators to order a new committee to look at ways to monitor and ameliorate stress. "We have to learn how to monitor this," says Provost Robert Brown. "But the question is: Will the faculty have time to read the report?"

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