

## PLANETARY SCIENCE

# Layers Within Layers Hint at a Wobbly Martian Climate

Like Earth, Mars has a layered geology, but the martian version can have a particularly rhythmic regularity; scientists are finally getting a handle on the mechanism driving it

For decades, planetary scientists assumed that the stunning layering of Mars goes back to the planet's innate unsteadiness. The planet wobbles and wanders in its orbit, changing the climate rhythmically. What else could shape the cyclic-looking layering in everything from icy polar deposits to crater fill? But without a time scale, researchers were long stymied in linking particular layering to any particular orbital variation. That left the door open for nonorbital explanations.

Now, new studies are tentatively tying layering to orbital variations. Across the polar caps of Mars and in impact craters, within the past few million years and several billion years ago, new observations and analyses are revealing periodic groupings of layers of the sort that orbitally driven climate change could have laid down. Martian layer counting is all the rage now, says planetary scientist Oded Aharonson of the California Institute of Technology (Caltech) in Pasadena. "That's a good sign."

Just identifying martian layering as periodic and not a random jumble has been controversial. On Earth, paleoceanographers can do hands-on work on sediment cores, analyzing them from the meter scale down to the atomic scale to date the layers precisely. On Mars, researchers must work from images taken from hundreds of kilometers up. They know that younger layers pile up on top of older ones, but they have no idea how long a given set of layers took to form. In the North Polar Layered Deposits (NPLD), for example, alternating dark and light layers exposed in cliff faces presumably reflect dust-darkened ice versus bright, nearly dust-free ice, but it gets more complicated. Dark stripes can be shadows, not dirty ice; frost can mask truly dark layers; and less-than-vertical outcrops can distort the apparent thickness of layers.

To avoid at least some of these problems, geophysicists J. Taylor Perron and Peter Huybers of Harvard University combined images

and topography returned from 23 strips across the NPLD by the now-defunct Mars Global Surveyor orbiter. Knowing the slope across layers let them correct apparent thickness to true thickness. As they reported at the Lunar and Planetary Science Conference (LPSC) in March in League City, Texas, most of the surveyed terrains did show—within a lot of climatic noise—periodic layering with a layer thickness of roughly 1.6 meters, although the periodicity waxed and waned with time. A layer in such cyclic bedding may have formed as the planet rhythmically nodded over on its side to 45° or even more—pouring more summer sun on the poles and sending polar ice to the equator. Then Mars would have righted itself and returned to its initial climate, forming a contrasting layer, all in one 120,000-year cycle. If so, the researchers calculate, the upper kilometer or so of the NPLD would have formed over tens of millions of years.

But Perron and Huybers are quick to point

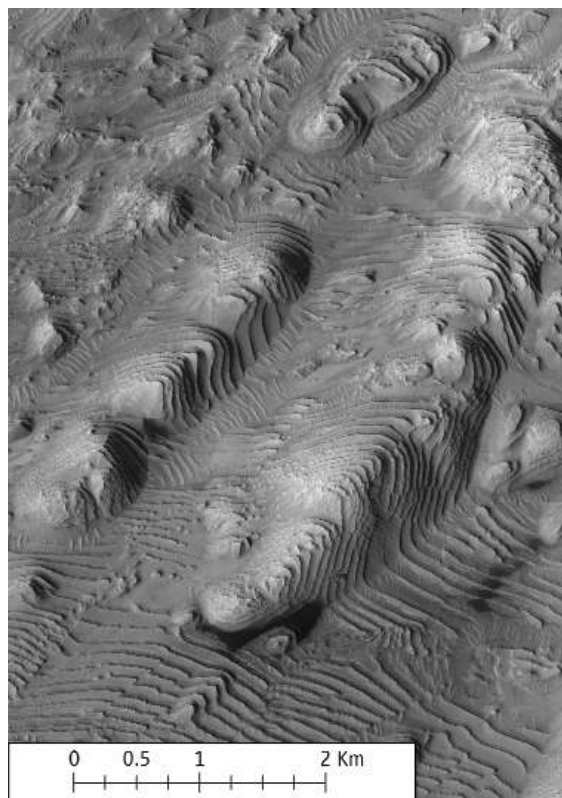
out that other, nonorbital processes could be modulating martian climate on a roughly periodic schedule, as El Niño does on Earth. To link layering to changes in orbit, they say, researchers must find a section of ice or rock in which layers change steadily if subtly in thickness or color in step with a longer term rhythm. For example, a series of thin layers might decrease in thickness in a rhythmic pattern that makes them stand out as a single packet. Such bundling could reflect the interaction between two orbital variations—for example, planetary tilt and the shape of Mars's orbit. Such an interaction would create a unique ratio of packet thickness to thin-layer thickness.

Such bundling ratios are starting to show up. As they report online this week in *Science* ([www.sciencemag.org/cgi/content/abstract/1157546](http://www.sciencemag.org/cgi/content/abstract/1157546)), planetary geophysicist Roger Phillips of the Southwest Research Institute in Boulder, Colorado, and colleagues analyzed data from SHARAD (SHAlow RADAR) onboard the Mars Reconnaissance Orbiter. They found periodic layering on two scales within broad reaches of the NPLD. SHARAD bombards the martian surface with high-frequency radio waves that easily penetrate pure ice but reflect back off dirty ice. The radar sounded out 45 to 50 thin layers beneath the ice's surface, divided into four packets by distinctive zones of low reflection.

So far, the group has two possible interpretations. The low-reflection regions could represent times when Mars's orbit grew rounder and less elliptical, causing storms loading the ice with dust to become less common. Or they could mark times of relatively small axial tilt over many tilt cycles. In either case, the researchers say, the entire NPLD probably formed over roughly the past 5 million years.

LPSC attendees also heard the first quantitative evidence that orbital variations drove climate and geology much earlier in martian history. Planetary scientists Kevin Lewis of Caltech and Aharonson reported their analysis of layering in the low-latitude Arabia Terra region of Mars. They found rhythmic bedding at several locations, all dating to roughly 4 billion years ago. In Becquerel crater, 3.5-meter layers were bundled into packets that average 36 meters in thickness. Lewis and Aharonson have not publicly linked that 10:1 bedding ratio to any particular orbital variations, but they noted in their LPSC talk that Mars's thin atmosphere and lack of oceans make cyclic climate change driven by internal, El Niño-like processes much less likely there than it is on Earth. Nailing down periodic layering on Mars will no doubt require a lot more layer counting and perhaps a better sense of martian time.

—RICHARD A. KERR



**Mars has rhythm.** Evidence is mounting that variations in the orbit of Mars drive cyclic climate changes that layer the planet.