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Ancient Mars probably too cold for liquid water

Planet's atmosphere was too thin to keep its surface consistently warm, analysis suggests.

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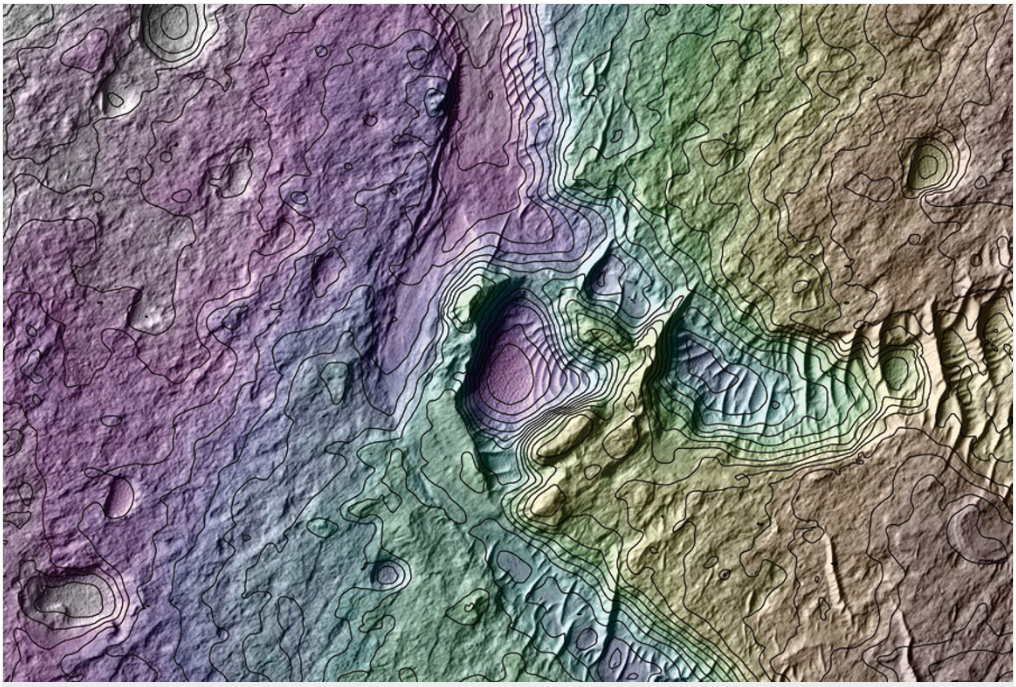

Antoine Lucas/NASA/JPL/Univ. Arizona

Craters on Mars hold clues to the planet's ancient environment.

Mars' atmosphere was probably never thick enough to keep temperatures on the planet's surface above freezing for the long term, suggests research published today in *Nature Geoscience*[1]. Although the planet's topography indicates that liquid water has flooded Mars in the distant past, evidence increasingly suggests that those episodes reflect occasional warm spells, not a consistently hospitable phase of the planet's history.

Signs of flowing water on Mars include layered sediments presumed to have been laid down in ancient lakes, as well as rugged canyons and lowlands apparently sculpted by massive floods. These have prompted researchers to suggest that the red planet, now frigid and dry, was warm and wet throughout its early history[2]. But that would have required an atmosphere much thicker than today's, a prospect that now seems unlikely, says Edwin Kite, a planetary scientist at Princeton University in New Jersey.

Kite and his colleagues say that the evidence against the idea that ancient Mars held a thick atmosphere for more than a few millennia at a time lies in the sizes of the planet's craters. If Mars had once possessed a denser atmosphere, they contend, small objects would have broken up as they passed through it — as they do in Earth's atmosphere, for example — rather than surviving largely intact to blast craters.

Using images from the Mars Reconnaissance Orbiter, the researchers catalogued more than 300 craters pockmarking an 84,000-square-kilometre area near the planet's equator. Ten per cent of the definite craters in that terrain — which has not changed much geologically for about 3.6 billion years — had diameters of 50 metres or less, and roughly 10% of features presumed to be the remnants of ancient craters were 21 metres across or smaller.

Then, the team used computer simulations of incoming objects pummeling Mars, trying the scenario with a range of atmospheric densities. Because the size of a crater would differ depending on the angle at which an object hits the surface, simply looking at the diameters of Mars' tiniest pockmarks would not give a true idea of the ancient atmosphere's density. Other factors such as the velocity of the incoming projectile, affect crater size as well, says Kite. "It's not the size of the smallest craters, but the size distribution of the entire population that's important," he notes.

According to the team's analysis, the surface pressure exerted by the ancient Martian atmosphere was probably no more than 150 times its current value. That means that the thickness of the atmosphere was less than one-third what some teams say would be needed to consistently keep Mars' surface above freezing, says Sanjoy Som, an astrobiologist with the Blue Marble Space Institute of Science at Moffett Field, California.

"This is an excellent paper," says James Head, a planetary scientist at Brown University in Providence, Rhode Island. "It bolsters previous studies that suggest early Mars was icy."

"It's clear that Mars was wet, but it's not so clear how it was warm," Som adds.

The most probable answer, Kite and his colleagues suggest, is that Mars was intermittently warm. Regular variations in the tilt of its axis could have warmed the planet and provided a protective atmosphere at times, they contend. But the atmosphere could also have been temporarily thickened by greenhouse gases from volcanic activity, or by gases released by large impacts from incoming objects. The heat generated by a sizable blast vaporizes any volatile substances in the planet's rocks or in the projectile itself.

Either of the last two scenarios could have thickened the atmosphere for decades or centuries, says Head. "That's plenty enough to get fluid flowing [on Mars]," he notes. According to one previous study[3], a 200-kilometre-wide object slamming into Mars would boost air pressure enough to keep the planet above freezing for around a century.

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References

1. Kite, E. S., Williams, J.-P., Lucas, A. & Aharonson, O. *Nature Geosci.* Advance online publication http://dx.doi.org/10.1038/ngeo2137 (2014).
2. Carr, M. H. *Nature* **326**, 30–35 (1987).
3. Segura, T. L., Toon, O. B., Colaprete, A. & Zahnle, K. *Science* **298**, 1977–1980 (2002).