Climate cycles may explain how running water carved Mars' surface features

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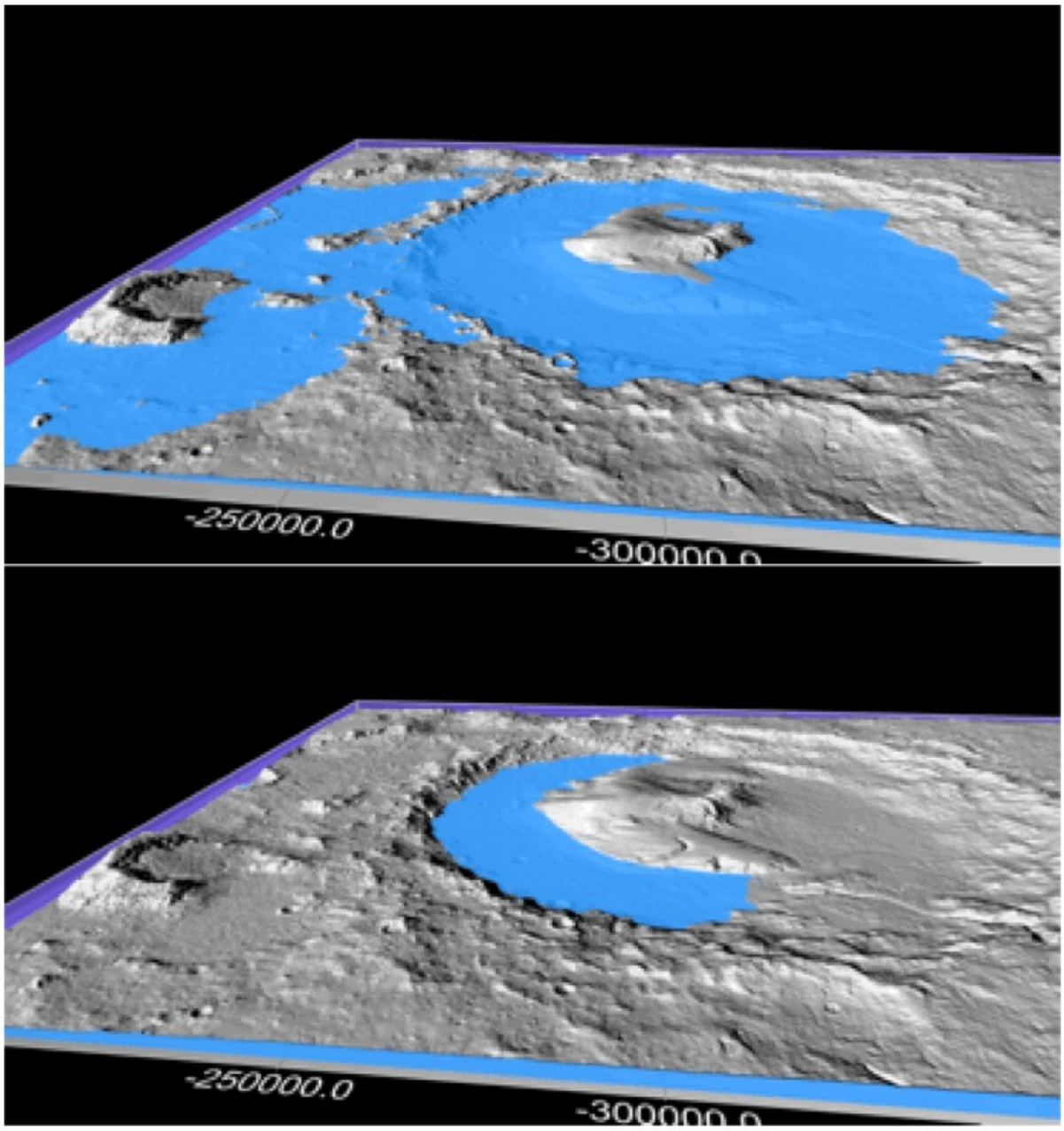

Gale Crater on surface of Mars was once filled with liquid water for 10,000 to 10 million years, according to findings from the Mars Science Laboratory (MLS). A new study from Penn State scientists suggests dramatic climate cycles may have produced warm periods long enough to thaw the planet and create the water features on the surface today. Topographic evidence for lakes in Gale Crater, abstract, 44th Lunar and Planetary Science Conference (2013). Credit: William Dietrich

Dramatic climate cycles on early Mars, triggered by buildup of greenhouse gases, may be the key to understanding how liquid water left its mark on the planet's surface, according to a team of planetary scientists.

Scientists have long debated how deep canyons and extensive valley networks—like the kinds carved by running water over millions of years on Earth—could form on Mars some 3.8 billion years ago, a time many believe the planet was frozen.

The researchers suggest a glacier-covered early Mars could have experienced long warm periods, lasting up to 10 million years at a time, caused by a thick atmosphere of carbon dioxide and hydrogen.

The team, which published its findings today (Dec. 1) in the journal *Earth and Planetary Science Letters*, found the warming cycles would have lasted long enough, and produced enough water, to create the features.

With the cycling hypothesis, you get these long periods of warmth that give you sufficient time to form all the different Martian valley networks," said Natasha Batalha, graduate student, astronomy and

astrophysics, Penn State.

Previous studies suggested asteroid impacts might have warmed the planet, creating steam atmospheres that led to rain. But those warm periods would have much shorter durations and struggle to produce enough water, researchers said.

"We think Mars had to be warm for millions to tens of millions of years, and the impact hypothesis can keep it warm for thousands of years," said Jim Kasting, Evan Pugh Professor of geosciences, Penn State, and paper co-author. "In terms of water, we need millions of meters of rainfall, and they (previous studies) can get hundreds of meters."

Kasting said valleys on the Martian surface are similar in width to the Colorado River Canyon. Scientists estimate it took 16 million years for the Colorado River, swollen seasonally as the snow melts in the Rocky Mountains, to carve the nearby Grand Canyon.

Using climate models, the team showed warming periods—caused when greenhouse gases reached a certain tipping point—lasted millions of years on Mars. With the right choice of parameters, these warm periods can last up to 10 million years.

According to researchers, greenhouse gases accumulated in the atmosphere gradually, belched by volcanic eruptions, released by cooling magma on the surface or seeping up from the planet's crust.

Rain naturally removes some of this from the atmosphere when it falls, storing some carbon in the ground through a process called chemical weathering. But because early Mars was cold, it rained less and this process couldn't keep up, the researchers said.

"Mars is in this precarious position where it's at the outer edge of the

habitable zone," Batalha said. "It's receiving less solar flux, so you start at a glaciated state. There is volcanic outgassing, but because you are colder, you don't get the same deposition of carbon back into the planet's surface. Instead, you get this atmospheric buildup and your planet slowly starts to rise in temperature."

As the planet warmed, chemical weathering would eventually happen faster than volcanoes could return gases into the atmosphere, and the planet would begin to cool, ushering in another ice age.

For the theory to work, scientists said further study is needed to determine whether enough carbon dioxide and hydrogen could have been produced on the planet.

"We would be well off if early Mars had plate tectonics just like Earth has today," Kasting said. "Then it works. But that's a big debate. A lot of people don't think Mars ever had it."

Batalha said high amounts of carbon dioxide in the atmosphere would have led to very acidic rain, which would have dissolved carbonate rocks at the surface and deposited them in the subsurface.

"So if the next Mars mission was able to dig down deeper, you might be able to uncover these different carbonates," she said. "That would be a sort of smoking gun for the carbon dioxide."

Provided by Pennsylvania State University