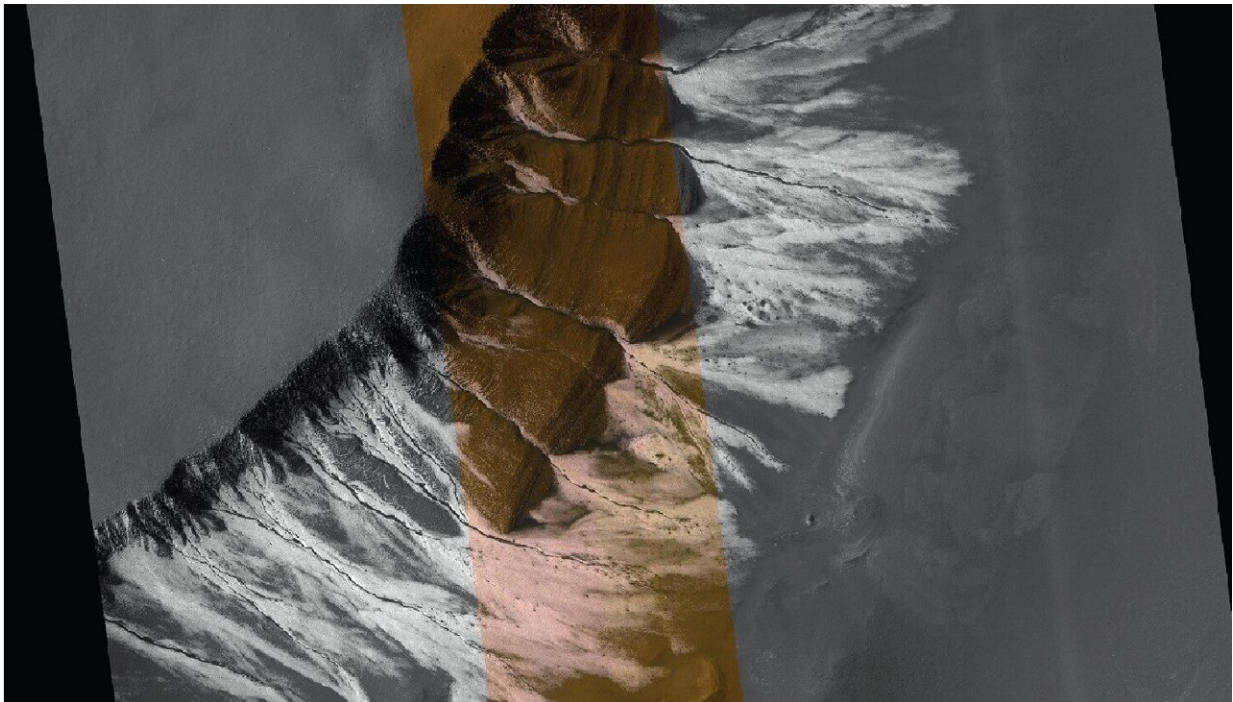


# Surprising insights about debris flows on Mars

March 14 2024

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Satellite image of gully landscapes on Mars, taken by HiRISE (High Resolution Imaging Experiment), a camera on board the Mars Reconnaissance Orbiter (photo no.: ESP\_039114\_1115). The white CO<sub>2</sub> ice is visible on the sides of the gullies. Credit: HiRISE (High Resolution Imaging Experiment), a camera on board the Mars Reconnaissance Orbiter (photo no.: ESP\_039114\_1115)

The period that liquid water was present on the surface of Mars may have been shorter than previously thought. Channel landforms called

gullies, previously thought to be formed exclusively by liquid water, can also be formed by the action of evaporating CO<sub>2</sub> ice.

That is the conclusion of a new study by Lonneke Roelofs, a planetary researcher at Utrecht University. "This influences our ideas about water on Mars in general, and therefore our search for life on the planet," Roelofs says.

The results of the study are [published](#) this week in the journal *Communications Earth and Environment*.

"The Martian atmosphere is 95% CO<sub>2</sub>," Roelofs explains. "In winter, [air temperatures](#) drop below -120 degrees Celsius, which is cold enough for CO<sub>2</sub> in the atmosphere to freeze." In the process of freezing, CO<sub>2</sub> gas can change directly to CO<sub>2</sub> ice, skipping the liquid phase.

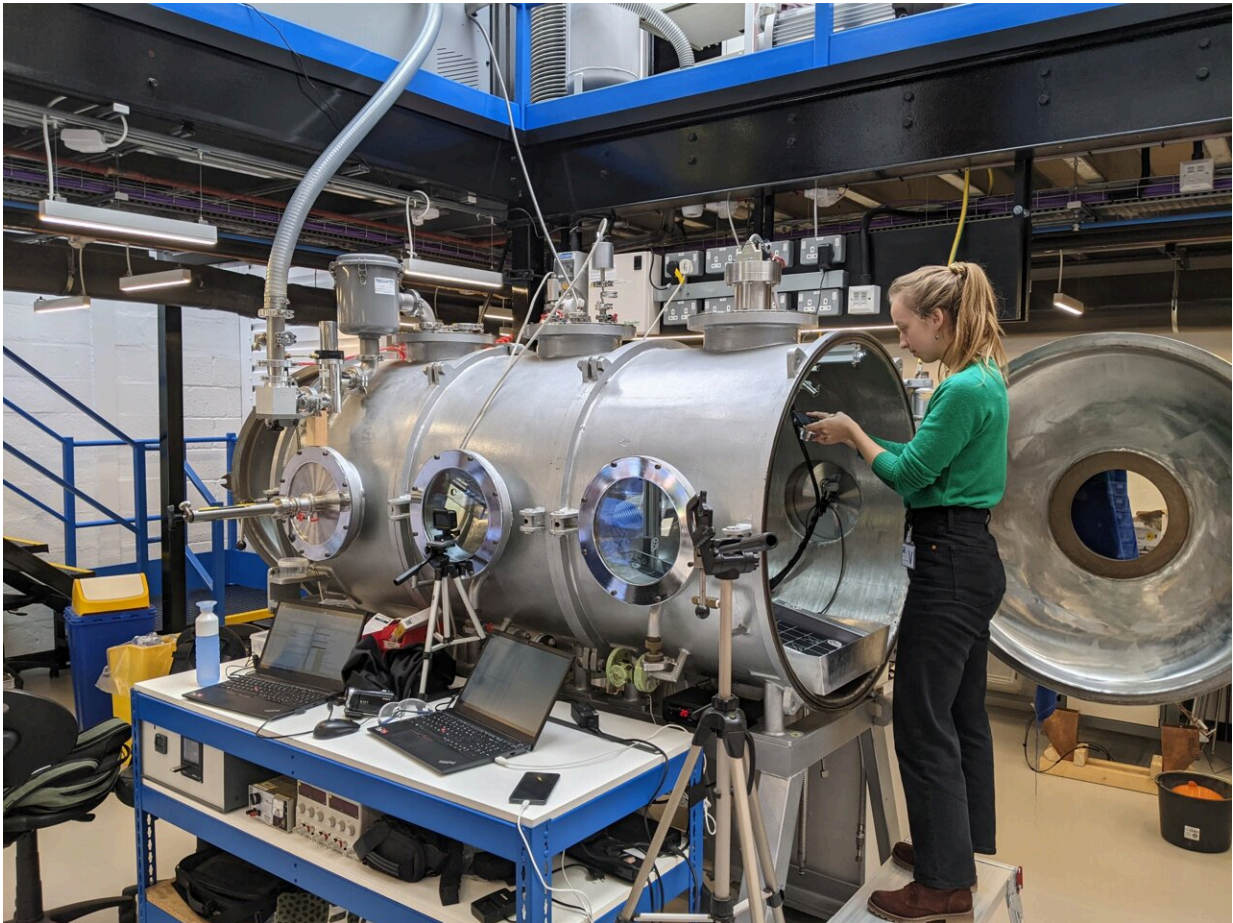
The process is similar to frost on Earth, where water vapor forms ice crystals and blankets the landscape in a white film. Warmer spring temperatures, combined with the thin Martian atmosphere, cause CO<sub>2</sub> ice to evaporate directly back to gas, again skipping the liquid phase.

"We call that 'sublimation.' The process is extremely explosive due to Mars' low air pressure. The created gas pressure pushes sediment grains apart causing the material to flow, similar to debris flows in [mountainous areas](#) on Earth. These flows can reshape the Martian landscape—even in the absence of water."

"The results of my research suggest that the chance of life having existed on Mars is smaller than previously thought."

Scientists have long hypothesized that CO<sub>2</sub> ice could be a [driving force](#) behind these Martian landscape structures. "But those hypotheses were mainly based on models or satellite studies," Roelofs explains.

"With our experiments in a so-called 'Mars chamber,' we were able to simulate this process under Martian conditions. Using this specialized lab equipment we could directly study this process with our own eyes. We even observed that debris flows driven by CO<sub>2</sub> ice under Martian conditions flow just as efficiently as the debris flows driven by water on Earth."



Lonneke Roelofs next to the Mars chamber at the Open University, Milton Keynes (UK). Credit: Mars chamber at the Open University, Milton Keynes (UK)

## Extraterrestrial life

"We know for sure that there was once water on the surface of Mars. This study does not prove the contrary," Roelofs says. "But the emergence of life likely needs a long period where liquid water was present. Previously, we thought that these landscape structures were formed by debris flows driven by water because of their similarity to debris flow systems on Earth."

"My research now shows that, in addition to debris flows powered by water, the sublimation of frozen CO<sub>2</sub> can also serve as a driving force behind the formation of these Martian gully landscapes. That pushes the presence of water on Mars further into the past, making the chance of life on Mars smaller." And that makes us even more unique than we thought.

## Why Mars?

But what makes someone interested in landscapes 330 million km away? "Mars is our closest neighbor. It's the only other rocky planet close to our solar system's 'green zone.' The zone is precisely far enough from the sun to allow for [liquid water](#) to exist, a prerequisite for life. So Mars is a place where we possibly can find answers to questions about how life developed, including potential [extraterrestrial life](#)," says Roelofs.

"Plus, studying the formation of landscape structures on other planets is a way for us to step outside our Earthly context. You ask different questions, which leads to new insights on processes here on Earth. For example, we can also observe the process of gas-driven [debris](#) flows in [pyroclastic flows](#) around volcanoes here on Earth. So this research could contribute to a better understanding of terrestrial volcanic hazards."

**More information:** Lonneke Roelofs et al, How, when and where current mass flows in Martian gullies are driven by CO<sub>2</sub> sublimation, *Communications Earth & Environment* (2024). [DOI: 10.1038/s43247-024-01298-7](https://doi.org/10.1038/s43247-024-01298-7)

Provided by Utrecht University

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