

How hard did it rain on Mars?

In a new study, geologists show there definitely was rainfall on Mars in the past – and that it was heavy enough to carve out many of the features we see today on the planet's surface. It reshaped the planet's impact craters and carved out river-like channels in its surface billions of years ago

In the paper, researchers from the Smithsonian Institution and the Johns Hopkins University Applied Physics Laboratory show that changes in the atmosphere on Mars made it rain harder and harder, which had a similar effect on the planet's surface as we see on Earth.

The fourth planet from the Sun, Mars has geological features like the Earth and Moon, such as craters and valleys, many of which were formed through rainfall. Although there is a growing body of evidence that there was once water on Mars, it does not rain there today.

But in their new study, geologists **Robert Craddock** and **Ralph Lorenz** show that there was rainfall in the past – and that it was heavy enough to change the planet's surface. To work this out, they used methods tried and tested here on Earth, where the erosive effect of the rain on the Earth's surface has important impacts on agriculture and the economy. Craddock said:

Many people have analyzed the nature of rainfall on the Earth, but no one had thought to apply the physics to understanding the early martian atmosphere.

To understand how rainfall on Mars has changed over time, the researchers had to consider how the martian atmosphere has changed. When Mars first formed 4.5 billion years ago, it had a much more substantial atmosphere with a higher pressure than it does now. This pressure influences the size of the raindrops and how hard they fall.

Early on in the planet's existence, water droplets would have been very small, producing something like fog rather than rain; this would not have been capable of carving out the planet we know today. As the atmospheric pressure decreased over millions of years, raindrops got bigger and rainfall became heavy enough to cut into the soil and start to alter the craters. The water could then be channelled and able to cut through the planet's surface, creating valleys.

Ralph Lorenz, who has also studied liquid methane rainfall on Saturn's moon Titan, the only other world in the solar system apart from Earth where rain falls onto the surface at the present day, explained:

By using basic physical principles to understand the relationship between the atmosphere, raindrop size and rainfall intensity, we have shown that Mars would have seen some pretty big raindrops that would have been able to make more drastic changes to the surface than the earlier fog-like droplets.

They showed that very early on, the atmospheric pressure on Mars would have been about 4 bars (the Earth's surface today is 1 bar) and the raindrops at this pressure could not have been bigger than 3mm across, which would not have penetrated the soil. But as the atmospheric pressure fell to 1.5 bars, the droplets could grow and fall harder, cutting into the soil. In Martian conditions at that time, had the pressure been the same as we have on Earth, raindrops would have been about 7.3mm – a millimetre bigger than on Earth.

There will always be some unknowns, of course, such as how high a storm cloud may have risen into the martian atmosphere, but it is unlikely that rainfall on early Mars would have been dramatically different than what's described in this paper. The findings provide new, more definitive, constraints about the history of water and the climate on Mars.



Valley networks on Mars show evidence for surface runoff driven by rainfall.



The tenuous atmosphere of Mars today visible on the horizon