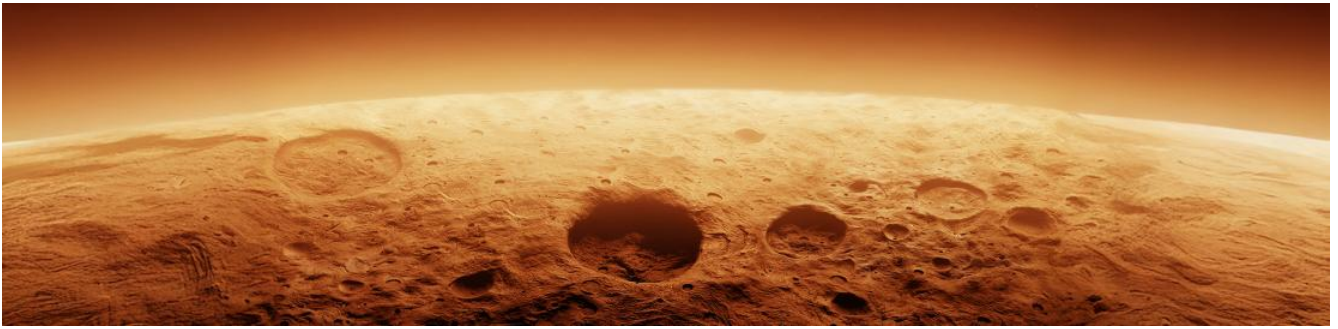




Mars time machine: researchers create virtual model to decode Red Planet's climate evolution

Researchers are creating advanced simulations that will provide a deeper understanding of Mars's climatic history and help to determine whether it was once able to sustain life.

27 February 2025 - By JONATHAN O'CALLAGHAN

An international team of researchers is developing a model of Mars's evolution that could unlock some of its long-held secrets, including whether it once harboured life.

François Forget, a space scientist from the Pierre Simon Laplace Institute in France, is the man looking for those answers. He is not a time traveller, but is hoping to do the next best thing.

His team of researchers, gathered under the name "Mars through time" and supported by EU funding, is trying to piece together different periods of the planet's history. The aim is to answer the question that has long perplexed scientists: was Mars once habitable?

"Mars was a place where life could have emerged, so it's very fascinating," said Forget, the principal investigator of Mars through time.

The work of his team is being coordinated at the French National Centre for Scientific Research in Paris. The six-year initiative, ending in November 2025, aims to shed light on the possible timeframes during which Mars might have been warm and wet, covered in glaciers, and maybe even suitable for life.

Previous missions to Mars have given a tentative look into its history, but have not shown what the planet was actually like. Robotic exploration has revealed that Mars was not always the desert planet it is today. It has witnessed eras conducive to rivers and lakes, as well as ice ages.

Yet we still know little about the climatic processes that have shaped its surface. This is where Forget's team comes in.

"We are trying to invent a new model, to build a virtual planet that evolves through time," said Forget. "It's a super ambitious project."

Work to develop this model has been underway since 2019, and proved more difficult to develop than initially thought – in part because of the large amount of computing power required. But the end is in sight.

"Now I know it's possible," he said. "I'm convinced that soon we will have a very nice tool available to the community."

That means we may soon be able to use this virtual time machine to transport ourselves to different periods of Martian history and understand exactly what happened to the planet and when.

A brief history of time

Like Earth, Mars was born at the dawn of our solar system, 4.5 billion years ago. It is about half the size of our own planet and is farther from the Sun than we are. At this distance, it receives less solar radiation than Earth does.

However, evidence increasingly suggests that early in its life, Mars was a warm and wet planet much like our own.

Geological and mineralogical evidence shows that Mars once possessed a thicker atmosphere than the planet has today. Even more intriguingly, we can also see remnants of ancient lakes and seas on its surface.

Two of these are currently being explored by the NASA rovers Curiosity and Perseverance.

At some point 3 to 4 billion years ago, Mars lost its atmosphere for reasons not yet fully understood, and with it, the temperate conditions that allowed liquid water to exist on its surface.

Today the planet is barren and dry, except for water thought to be trapped under its surface, and ice that we can see frozen at its poles.

When exactly the planet was warm and wet is still an open question.

"We do not understand the climate process that allowed that," said Forget, and points out a crucial issue to explore. "Liquid water means there was a possibility of the emergence of life at the same time life emerged on Earth."

Mars is also thought to have gone through periods of vast glaciation, carving valleys on its surface, when the atmosphere temporarily disappeared.

Forget's model is hoping to give insight into when these periods occurred. It will be able to do that with a precision unlike any previous Mars climate models. The current models provide just a snapshot of the climate at any given moment.

"We're trying to have a new model that can simulate the evolution of Mars for thousands or millions of years," said Forget. "When we do that, we can simulate the evolution of glaciers and lakes."

Atmospheric changes

To develop the model, Forget and his team take known information about Mars and use powerful computers to simulate the conditions on its surface that this might have led to.

For example, one known major changing factor on Mars has been its obliquity, the tilt of the planet as it orbits the Sun.

Currently, it is about 25 degrees, similar to Earth, but it has varied throughout its history from almost zero degrees to more than 60 degrees, said Forget. This has caused large swings in the amount of heat on Mars's surface.

The thickness and composition of the Martian atmosphere over time is also an open question. Today the planet's atmosphere is about 1% of the Earth's volume, with 95% of it made up of CO₂.

"We used to think that if you add enough CO₂, you will have a warm climate," said Forget. "But that is not sufficient. There is something else that allowed a warm climate."

The current thinking is that ancient volcanism on Mars expelled a considerable amount of hydrogen into the atmosphere, which, combined with CO₂, could make a sufficient greenhouse effect. "But it's very speculative. There is a mystery there," Forget points out.

Large impacts, like collisions with asteroids or comets, could also have influenced Mars's climate. "With our tools, we can model that," said Forget. Evidence of those impacts is visible today as craters on the planet's surface.

Faces of Mars

While Mars is barren today, it has shown many faces in the past.

"Through geological records that we can interpret with models, we explore '50 different planets' – an icy planet covered with glaciers, a planet with an atmosphere completely frozen at the poles, and a planet with no atmosphere," said Forget.

That makes this research applicable not just to Mars, but to planets orbiting other stars too, with the underlying idea of looking for habitable environments beyond our solar system.

"The limit of habitability is a big topic," he said. "We can explore what it takes for a planet like Earth to have liquid water on its surface. We want to define where water will stabilise."

Understanding Mars will give us an opportunity to gain such knowledge.

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