Sulfur dioxide may have helped maintain a warm early Mars

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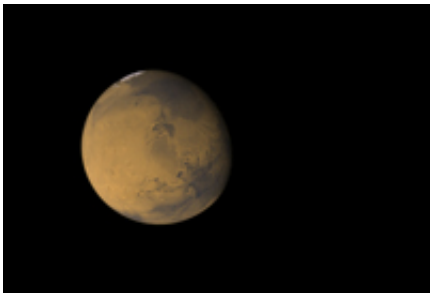

Sulfur dioxide (SO_2) may have played a key role in the climate and geochemistry of early Mars, geoscientists at Harvard University and the Massachusetts Institute of Technology suggest in the Dec. 21 issue of the journal *Science*. Their hypothesis may resolve longstanding questions about evidence that the climate of the Red Planet was once much warmer than it is today.

The Science paper's authors are Itay Halevy, a Ph.D. candidate in Harvard's Department of Earth and Planetary Sciences; Daniel Schrag, professor of earth and planetary sciences and environmental engineering at Harvard; and Maria Zuber, professor of earth, atmospheric, and planetary sciences at MIT.

"There is abundant evidence for a warmer climate, perhaps even a liquid

water ocean, early in Martian history, between 3.5 and 4 billion years ago," says Schrag, the paper's senior author. "However, scientists have found it difficult to reconcile this evidence with our understanding of how the climate system is regulated on Earth."

Over millions of years, the Earth's climate has been controlled by the carbon cycle and its effect on carbon dioxide, the main greenhouse gas. On Earth, there is a balance between carbon dioxide vented from volcanoes and chemical reactions with silicate rocks on the Earth's surface that remove carbon dioxide from the atmosphere and convert it to calcium carbonate, commonly known as limestone. Scientists believe that this balance has helped maintain Earth's habitability over the last 4 billion years.

On Mars, there is not enough volcanic activity today to maintain this cycle. But this was not true some 4 billion years ago, when a giant volcanic complex called Tharsis erupted over tens to hundreds of millions of years -- and also a time when evidence suggests Mars had a much warmer climate. However, this carbon cycle on early Mars should have produced vast quantities of limestone like on Earth, and yet almost none has been found.

The new hypothesis points the finger at sulfur dioxide, another gas released by volcanoes. Sulfur dioxide is a powerful greenhouse gas, like carbon dioxide, and it is more reactive with silicate rocks than carbon dioxide. On Earth, sulfur dioxide is rapidly oxidized to sulfate, and then removed from the atmosphere. The authors argue that the atmosphere of early Mars would have lacked oxygen, so sulfur dioxide would remain much, much longer.

"The sulfur dioxide would essentially preempt the role of carbon dioxide in surface weathering reactions," says Halevy, the first author of the report. "The presence of even a small amount of sulfur dioxide in the

atmosphere would contribute to the warmer climate, and also prevent limestone deposits from forming."

In place of limestone, the authors predict that sulfur minerals would form in any standing water on Mars. This may explain the surprising finding of the rovers that have identified sulfur minerals as an abundant component of Martian soils.

"We think we now understand why there is so little carbonate on Mars, and so much sulfur," Halevy says.

"Our hypothesis may also be important for understanding the early Earth," Schrag says. "Before the origin of life, our atmosphere may have looked much like early Mars. Sulfur dioxide may have had an important role then as well."

If correct, the hypothesis implies that the oceans in which life evolved were much more acidic than previously thought. The early Earth may also provide a test for the hypothesis through the analysis of isotopes of sulfur in ancient mineral deposits.

Source: Harvard University