Detailed model suggests organic matter on Mars was formed from atmospheric formaldehyde

September 19 2024

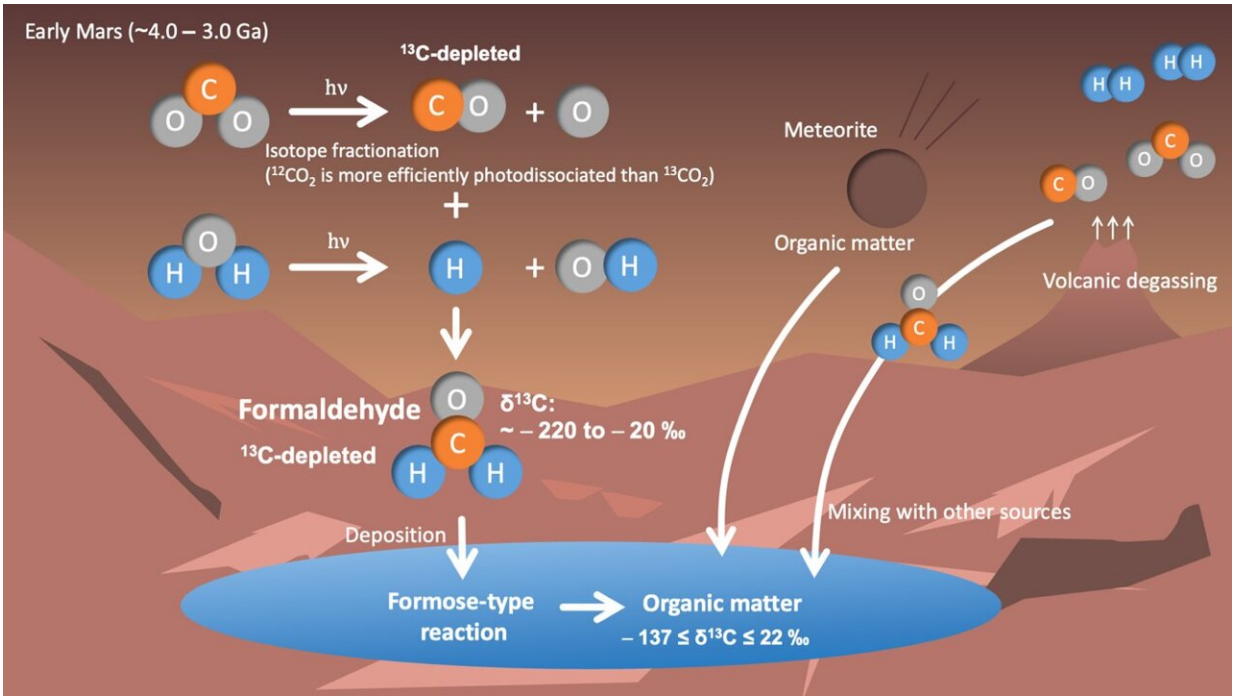

Diagram showing the processes of how organic matter was formed on early Mars. Credit: Shungo Koyama

Although Mars is currently a cold, dry planet, geological evidence suggests that liquid water existed there around 3 to 4 billion years ago. Where there is water, there is usually life. In their quest to answer the

burning question about life on Mars, researchers at Tohoku University created a detailed model of organic matter production in the ancient Martian atmosphere.

Organic matter refers to the remains of living things such as plants and animals, or the byproduct of certain chemical reactions. Whatever the case, the stable carbon isotope ratio ($^{13}C/^{12}C$) found in organic matter provides valuable clues about how these building blocks of life were originally formed, giving scientists a window into the past.

As such, it has become a point of interest for Mars expeditions. For example, the Mars rover Curiosity (operated by NASA) revealed that organic matter found in sediments from that era on Mars are unusually depleted in ^{13}C. It was also discovered that the carbon isotope ratios varied significantly between samples. However, the reason for this variability was a mystery.

To expand on these findings, a research group led by Shungo Koyama, Tatsuya Yoshida, and Naoki Terada from Tohoku University developed a Martian atmospheric evolution model. Their study is published in the journal *Scientific Reports*.

The model focused on formaldehyde (H_2CO), which members of this research team previously determined could feasibly be produced in the ancient Martian atmosphere.

The reason for this choice is that formaldehyde can generate complex organic compounds such as sugars, which are essential for life. In other words, formaldehyde may be the missing factor that could explain the anomalous values of the Curiosity rover samples. It could also be a sign of past life.

This model combined a photochemical model with a climate model to

estimate the changes in the carbon isotope ratio of formaldehyde on Mars, dating back 3 to 4 billion years. It revealed that the depletion of ^{13}C in formaldehyde is due to the photodissociation of CO_2 by solar ultraviolet radiation, which results in the preference of one stable isotope over another.

The study also showed that the carbon isotope ratio varied based on factors such as the atmospheric pressure on Mars at the time, the fraction of light reflected by the planet's surface, the ratio of CO to CO_2, and the amount of hydrogen released by volcanic activity.

"This model provides a possible explanation for previously unexplained findings, such as why ^{13}C was mysteriously depleted," remarks Koyama, a graduate student at Tohoku University.

This discovery indicates that formaldehyde contributed to the formation of organic matter on ancient Mars, implying that bio-important molecules such as sugars and ribose (a component of RNA, which is present in all living cells) may have been produced on the planet.

More information: Shungo Koyama et al, Stable carbon isotope evolution of formaldehyde on early Mars, *Scientific Reports* (2024). DOI: 10.1038/s41598-024-71301-w

Provided by Tohoku University