ASTRO SCIENCE JOURNAL FOR KIDS

MAY 2023

What can we learn from carbon on Mars?

Authors:
Jennifer C. Stern, Charles A. Malespin, Jennifer L. Eigenbrode, and others

Associate Editors:
Miranda Wilson and Fiona Firth

Abstract

LOWER READING LEVEL

Mars is dry and cold. It doesn't have much of an atmosphere. But what was it like in the past? Did Mars ever have an environment that could support life? Luckily, we have rovers on the surface of Mars that can help us answer these questions.

Carbon is a key component of living things. So, we used the Curiosity Rover on Mars to sample the surface for carbon. We sampled in an area that might have been a dried-up lake bed. We looked at the carbon to see how much there was and where it came from. This could give us clues about what the environment used to be like. It could also help us figure out if there used to be living things in the area. We found that there was more carbon on Mars than we expected. Most of the carbon probably came from meteorites and rocks. We can't rule out that it came from living things, but we need a lot more information to help us figure it out.

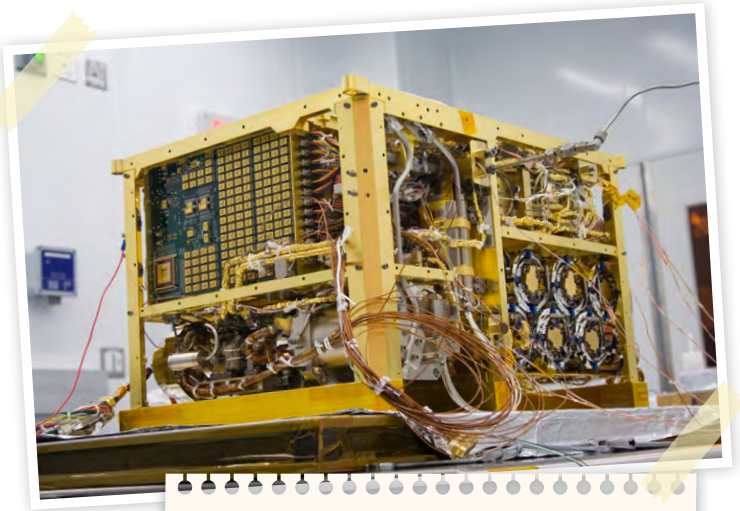
Introduction

We know a lot about Earth and what lives on our planet. But we don't know as much about other planets. They take a long time to get to and aren't very friendly to humans, either. Our closest planet, Mars, has fascinated scientists for a long time. They are very curious about whether Mars ever had life on it, or if it could support life in the future.

How do scientists answer these questions? Well, in 2012 NASA landed a rover named Curiosity on the surface of Mars. It is still there today. Curiosity is a special rover because it was designed to do science experiments. It has instruments that can figure out what **elements** are on the surface of Mars. It has a drill to help break apart rocks. Curiosity also has lots of cameras to take detailed photos of the planet's surface.

Curiosity also has a built-in science laboratory. It is called the Sample Analysis at Mars (SAM).

We used SAM to help us figure out if there could have ever been life on Mars. We picked a spot in the Yellowknife Bay Formation on the planet. It looks like it could have been a lake-like environment in the past. Living things need water. So, if there is any evidence that there was life on Mars, this is a good spot to search.



The Sample Analysis at Mars (SAM) instrument is a science laboratory on the Curiosity rover. This is a picture from before it was installed.
Images: NASA/GSFC

Methods

Giving instructions to the Curiosity Rover is complicated. Before we asked Curiosity to take any samples, we needed a good plan for our experiment.

We know that life contains the element carbon. Lots of chemical reactions in living things use carbon, too. So, we decided to search for carbon on Mars. Unfortunately, lots of other things also contain carbon – for example, some volcanic rocks and **meteorites**. If we found carbon in our sample, we needed a way to figure out where it might have come from.

We know carbon **atoms** can come in different forms that we call **isotopes**. The forms weigh different amounts, but they have all the same properties. There are two common isotopes of carbon, carbon-12 and carbon-13 (see Fig. 1). Carbon-13 is heavier. The instruments on SAM can tell us how much of each isotope is in a sample. Things that contain carbon might have different amounts of these isotopes.

Scientists think that over 200 meteorites from Mars have landed on Earth! Scientists measured the amount of carbon in some of them. Our tests on Mars produced more carbon than the tests on the meteorites.

Next, we needed an easy way to compare our samples. One way is to compare them all to a **standard**. A standard is a sample where we know how much of each carbon isotope it has. We can use the standard to calculate a number that is easy to compare. This is the **carbon isotope value**. We already know the carbon isotope values for things like Martian meteorites and volcanic rocks. There is also a range of carbon isotope values for living things. We can use this to learn more about the carbon in our sample.

Once we worked out our plan, we sent instructions to Curiosity. SAM took a sample and measured the carbon isotopes. SAM does this by heating the rock in an oven and looking at the gases that are produced. Back on Earth, we calculated the carbon isotope values for our sample.

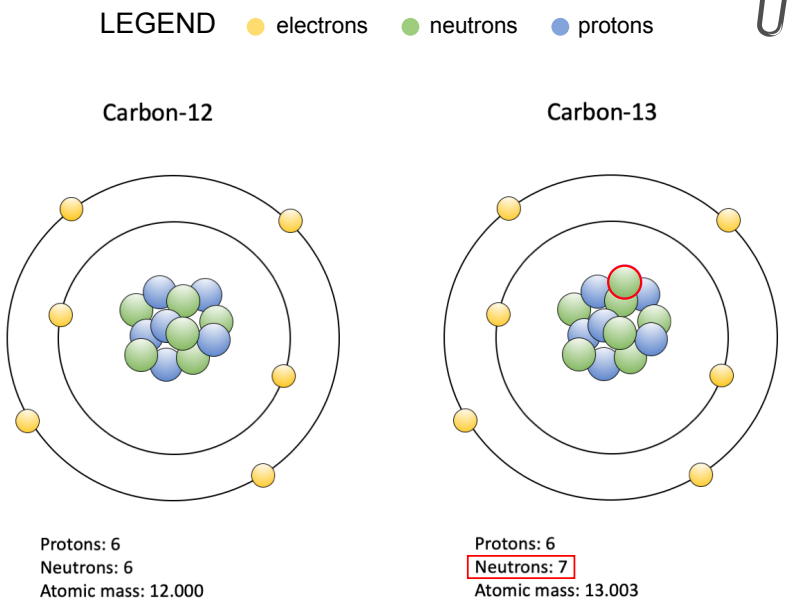


Figure 1:
Carbon-12 and carbon-13 isotopes. Carbon-13 weighs more because it contains one more neutron than carbon-12. We can use the amount of these isotopes in a sample to figure out where the carbon originally came from.
Images: Jansen Smith, CC BY-SA 3.0

Results

We found a lot of carbon in our sample. In fact, we found forty times as much carbon as previous experiments that had slightly different steps. We know that some of our carbon was left over after previous experiments. There are no people on Mars to help clean out our instruments!

The rest of the carbon we found matches carbon isotope values from a lot of sources. They match meteorites from Mars. They also match **carbonate**, which is a chemical found in lots of rocks. The carbon isotope values we found in our sample are also within the range of living things.

Discussion

We found a lot more carbon than we expected in our sample from Mars. That means there's enough carbon on Mars for plenty of chemical reactions. It's possible that some of these reactions could have been in living things.

The carbon isotope values we calculated matched a lot of different sources. These include meteorites, carbonate, and living things. We know that a lot of the carbon isotope values overlap. So, there's no way to tell how much carbon came from which source. There's a chance that our carbon came from living things! But it is more likely that most of our carbon came from other sources.

We would like to do more studies to learn about how carbon formed on Mars. We would also like to understand how that carbon changed over time. These things would help us understand the history of Mars better.

Conclusion

Scientists have always wondered if we are alone in the universe. As we explore more of space, we will likely keep looking for life. Our study showed a lot of possibilities for the source of carbon on Mars. We can't say for sure that it came from living things, but we can't rule it out.

You can learn more about Mars on NASA's Mars Exploration Program Website. You can find out about missions and look at pictures taken by the rovers. You can also learn more about all the newest research on Mars!

Glossary of Key Terms

Atom - a basic building block of matter. Atoms are the smallest parts of elements. They are very tiny and are made up of protons, electrons, and neutrons. For example, carbon-12 has 6 protons, 6 electrons, and 6 neutrons. Carbon-13 has 6 protons, 6 electrons, and 7 neutrons.

Carbonate - a type of molecule that contains carbon (not organic). They are components of many types of rocks that have carbon in them.

Carbon isotope value - the ratio of carbon-13 to carbon-12 in a sample relative to a standard. The standard is a sample of limestone rock that has carbon. It is called the Pee-Dee Belemnite.

Element - a pure substance that is made from a lot of atoms. The atoms are all the same type. Some examples of elements are carbon, oxygen, hydrogen, gold, and iron.

Isotope - an atom that weighs a different amount than other atoms of the same element. They still have the same chemical properties.

Meteorite - a rock that falls to a planet from space. These rocks are usually very old. They are older than anything found on the surface of the planet they land on. They might come from other planets or asteroids or comets in our solar system.

Standard - a material that contains a known amount of a substance. If the amount of a substance is unknown in a sample, researchers can compare it with a standard to find out.

Check your understanding

1. Where did we get our samples from? Why did we choose that spot?

2. Why did we need to make sure we had a good plan before starting our experiment?

3. Where is the carbon in the sample most likely from?

4. Find a partner and brainstorm. What do organisms need to survive? Do you think that Mars might have had these things in the past?

5. Why do you think it is difficult to do research on Mars?

REFERENCES

Jennifer C. Stern, Charles A. Malespin, Jennifer L. Eigenbrode, Christopher R. Webster, Greg Flesch, Heather B. Franz, Heather V. Graham, Christopher H. House, Brad Sutter, Paul Douglas Archer Jr., Amy E. Hofmann, Amy C. McAdam, Douglas W. Ming, Rafael Navarro-Gonzalez, Andrew Steele, Caroline Freissinet, and Paul R. Mahaffy (2022) *Organic carbon concentrations in 3.5-billion-year-old lacustrine mudstones of Mars*. Proceedings of the National Academy of Sciences of the United States of America.
https://www.pnas.org/doi/suppl/10.1073/pnas.2201139119

Curiosity News: NASA's Curiosity takes inventory of key life ingredient on Mars
https://mars.nasa.gov/news/9214/nasas-curiosity-takes-inventory-of-key-life-ingredient-on-mars/?site=msl

Scientific American: Life on Mars may have been its own worst enemy
https://www.scientificamerican.com/article/life-on-mars-may-have-been-its-own-worst-enemy

NASA Mars Exploration Program
https://mars.nasa.gov/

Acknowledgement: This article's adaptation was supported by the GM Foundation.