Two meteorites are providing a detailed look into outer space

March 26 2023

Credit: Pixabay/CC0 Public Domain

If you've ever seen a shooting star, you might have actually seen a meteor on its way to Earth. Those that land here are called meteorites and can be used to peek back in time, into the far corners of outer space or at the earliest building blocks of life. Today, scientists report some of the most detailed analyses yet of the organic material of two meteorites. They've identified tens of thousands of molecular "puzzle pieces," including a larger amount of oxygen atoms than they had expected.

The researchers will present their results at the spring meeting of the American Chemical Society (ACS). ACS Spring 2023 is a hybrid meeting being held virtually and in-person March 26–30.

Previously, the team led by Alan Marshall, Ph.D., investigated complex mixtures of organic materials found on Earth, including petroleum. But now, they are turning their attention toward the skies—or the things that have fallen from them. Their ultra-high resolution mass spectrometry (MS) technique is starting to reveal new information about the universe and could ultimately provide a window into the origin of life itself.

"This analysis gives us an idea of what's out there, what we're going to run into as we move forward as a 'spacefaring' species," says Joseph Frye-Jones, a graduate student who is presenting the work at the meeting. Both Marshall and Frye-Jones are at Florida State University and the National High Magnetic Field Laboratory.

Thousands of meteorites fall to Earth every year, but only a rare few are "carbonaceous chondrites," the category of space rock that contains the most organic, or carbon-containing, material. One of the most famous is the "Murchison" meteorite, which fell in Australia in 1969 and has been studied extensively since. A newer entry is the relatively unexplored "Aguas Zarcas," which fell in Costa Rica in 2019, bursting through back porches and even a doghouse as its pieces fell to the ground. By understanding the organic makeup of these meteorites, researchers can obtain information about where and when the rocks formed, and what they ran into on their journey through space.

To make sense of the complicated jumble of molecules on the meteorites, the scientists turned to MS. This technique blasts a sample apart into tiny particles, then basically reports the mass of each one, represented as a peak. By analyzing the collection of peaks, or the spectrum, scientists can learn what was in the original sample. But in many cases, the resolution of the spectrum is only good enough to confirm the presence of a compound that was already presumed to be there, rather than providing information about unknown components.

This is where Fourier-transform ion cyclotron resonance (FT-ICR) MS comes in, which is also known as "ultra-high resolution" MS. It can analyze incredibly complex mixtures with very high levels of resolution and accuracy. It's especially well suited for analyzing mixtures, like petroleum, or the complex organic material extracted from a meteorite. "With this instrument, we really have the resolution to look at everything in many kinds of samples," says Frye-Jones.

The researchers extracted the organic material from samples of both the Murchison and Aguas Zarcas meteorites, then analyzed it with ultra-high resolution MS. Rather than analyzing only one specific class of molecules at a time, such as amino acids, they chose to look at all soluble organic material at once. This provided the team with more than 30,000 peaks for each meteorite to analyze, and over 60% of them could be given a unique molecular formula. Frye-Jones says these results represent the first analysis of this type on the Aguas Zarcas meteorite, and the highest-resolution analysis on the Murchison one. In fact, this team identified nearly twice as many molecular formulas as previously reported for the older meteorite.

Once determined, the data were sorted into unique groups based on various characteristics, such as whether they included oxygen or sulfur, or whether they potentially contained a ring structure or double bonds. They were surprised to find a large amount of oxygen content among the compounds. "You don't think of oxygen-containing organics as being a big part of meteorites," explained Marshall.

The researchers will next turn their attention to two far more precious samples: a few grams of lunar dust from the Apollo 12 and 14 missions of 1969 and 1971, respectively. These samples predate Marshall's invention of FT-ICR MS in the early 1970s. Instrumentation has come a long way in the decades since and is now perfectly poised to analyze these powders. The team will soon compare their results from the meteorite analyses to the data they obtain from the lunar samples, hoping to learn more information about where the moon's surface came from. "Was it from meteorites? Solar radiation? We should be able to soon shed some light on that," says Marshall.

More information: ACS Spring 2023: Molecular characterization of soluble organic material from meteorites by 21T FT-ICR MS

Provided by American Chemical Society

Citation: Two meteorites are providing a detailed look into outer space (2023, March 26) retrieved 31 October 2024 from https://phys.org/news/2023-03-meteorites-outer-space.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.