Meteorites: Why study them? What can they teach us about finding life beyond Earth?

April 1 2024, by Laurence Tognetti

Morgan Nunn Martinez, who was a PhD student at UC San Diego, and Dr. Alex Meshik seen photographing and measuring a meteorite specimen in Antarctica's Miller Range during the 2013-2014 Antarctic Search for Meteorites (ANSMET) program field season. Credit: NASA/JSC/ANSMET

Universe Today has explored the importance of studying impact craters,

planetary surfaces, exoplanets, astrobiology, solar physics, comets, planetary atmospheres, planetary geophysics, and cosmochemistry, and how this myriad of intricately linked scientific disciplines can assist us in better understanding our place in the cosmos and searching for life beyond Earth.

Here, we will discuss the incredible research field of meteorites and how they help researchers better understand the history of both our solar system and the cosmos, including the benefits and challenges, finding life beyond Earth, and potential routes for upcoming students who wish to pursue studying meteorites. So, why is it so important to study meteorites?

Dr. Alex Ruzicka, who is a Professor in the Department of Geology at Portland State University, tells Universe Today, "They provide our best information about how the solar system formed and evolved. This includes planet formation. We also obtain information on astrophysics (stellar processes) through studies of pre-solar grains."

There is often confusion regarding the differences between an asteroid, meteor, and meteorite, so it's important to explain their respective differences to help better understand why scientists study meteorites and how they study them. An asteroid is a physical, orbiting planetary body that is primarily comprised of rock, but can sometimes be comprised of additional water ice, with most asteroids orbiting in the Main Asteroid Belt between Mars and Jupiter and the remaining orbiting as Trojan Asteroids in the orbit of Jupiter or in the Kuiper Belt with Pluto.

A meteor is the visual phenomena that an asteroid produces as it burns up in a planet's atmosphere, often seen as varying colors from the minerals within the asteroid when heated up. The pieces of the asteroid that survive the fiery entry and hit the ground are called meteorites, which scientists' study to try and learn about the larger asteroid body it

came from, and where that asteroid could have come from, as well. But what are some of the benefits and challenges of studying meteorites?

Dr. Ruzicka tells Universe Today, "Benefits: scientific knowledge, information on potential resources (e.g., metals, water) for humans to utilize, information on how to link meteorites and asteroids, which can provide information on space collision hazards for Earth. Challenges: compared to Earth rocks, we lack field evidence for their source bodies and parent bodies (how they relate to other rocks), we have to factor in the element of time that is longer for space rocks than for Earth rocks, and sometimes we are dealing with formation environments completely unlikely what we have on Earth. So, the challenges are big and many."

According to NASA, more than 50,000 meteorites have been retrieved from all over the world, ranging from the deserts of Africa to the snowy plains of Antarctica. In terms of their origins, it is estimated that 99.8% of these meteorites have come from asteroids, with 0.1% coming from the moon and 0.1% coming from Mars.

The reason why we've found meteorites from the moon and Mars is due to pieces of these planetary bodies being catapulted off their surfaces (or sub-surfaces) after experiencing large impacts of their own, and these pieces then travel through the solar system for thousands, if not millions, of years before being caught in Earth's gravity and the rest is history. Therefore, with meteorites originating from multiple locations throughout the solar system, what can meteorites teach us about finding life beyond Earth?

"That the ingredients for making life formed in space and were delivered to Earth," Dr. Ruzicka tells Universe Today. "We know organic molecules formed in gas clouds, were incorporated in our solar system, and processed in asteroidal and cometary bodies under higher temperatures in the presence of water. These were then delivered to

Earth which wouldn't have been very hospitable in early times due to sterilizing impacts. We also know that there must have been a lot of planetary rock swapping early when impact rates were high. Life itself may have been transplanted to Earth from Mars."

As it turns out, one of the most fascinating meteorites ever recovered did come from Mars, which was identified as ALH84001, as it was found in Allan Hills of Antarctica on December 27, 1984, during the 1984–85 field season where researchers from all over the world gather in Antarctica to search for meteorites using snowmobiles. Despite being collected in 1984, it wasn't until 1996 that a team of scientists discovered what initially appeared to be evidence of microscopic bacteria fossils within the 1.93-kilogram (4.25-pound) meteorite.

This immediately made headlines across the globe, resulting in countless non-scientific claims that these microfossils were clear evidence of life on Mars. However, both the researchers of the initial study and the scientific community were quick to point out the unlikelihood that these features resulted from life based on other observations made about ALH84001. For example, while ALH84001 is estimated to be 4.5 billion years old, which is when Mars is hypothesized to have possessed liquid water on its surface, radiometric dating techniques revealed that ALH84001 was catapulted off Mars approximately 17 million years ago and landed on Earth approximately 13,000 years ago.

ALH84001, which is one of the most famous meteorites ever recovered, helped catapult the field of astrobiology to new heights when scientists uncovered what initially appeared to be microscopic bacteria fossils within this meteorite, though those findings remain inconclusive to this day. Credit: NASA

To this day, there has been no clear evidence that ALH84001 ever contained traces of life. Despite this, ALH84001 has nonetheless helped launch the field of astrobiology into new heights, with present-day scientists claiming this one meteorite was the reason they pursued their career path to find life beyond Earth. But what have been the most exciting aspects about meteorites that Dr. Ruzicka has studied throughout his career?

Dr. Ruzicka tells Universe Today, "A lot is interesting, what's most

exciting? That's hard to say. I get satisfaction from taking clues left by the rocks to figure out or constrain the processes that formed them. I am engaged in a meteoritic version of CSI, we can call it MSI (for meteoritic scene investigation)."

Like many scientific fields, this "meteoritic version of CSI" requires individuals from a myriad of backgrounds and disciplines, including geology, physics, geochemistry, cosmochemistry, mineralogy, and artificial intelligence, just to name a few, with the aforementioned radiometric dating frequently used to estimate the ages of meteorites by measuring the radioactive isotopes within the sample. It is through this constant collaboration and innovation that scientists continue to unlock the secrets of meteorites with the goal of understanding their origins and compositions, along with how our solar system, and life on Earth (and possibly elsewhere), came to be. Therefore, what advice can Dr. Ruzicka offer upcoming students who wish to pursue studying meteorites?

Dr. Ruzicka tells Universe Today, "Work hard and pursue your dreams. Find a rigorous program of study because it will come in handy."

While meteorites are space rocks that crash land on Earth after traveling through the heavens for millions, and possibly billions, of years, these incredible geologic specimens are slowly helping scientists' piece together the origins of the solar system and beyond, and even how life might have come to be on our small, blue world, and possibly elsewhere. With a myriad of tools and instruments at their disposal, scientists from all over the world will continue to study meteorites in hopes of answering the universe's toughest questions.

Dr. Ruzicka concludes by telling Universe Today, "Rocks from space are the best kinds of rocks to study. Way more cool than most rocks on Earth because they are in some ways more puzzling."

Provided by Universe Today