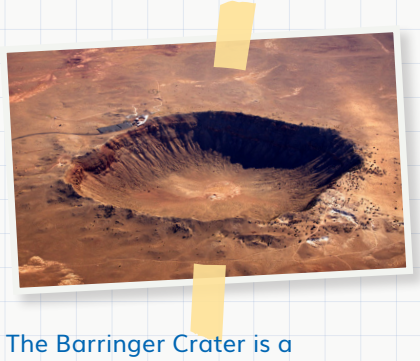
Session 4 Space Rocks and Earth Rocks



The Barringer Crater is a large meteor impact crater in northern Arizona.

ABSTRACT

Space is full of **meteoroids**—or objects that can be as small as a grain of sand or as big as 100 meters—**comets**, and **asteroids**, which are even bigger. Meteorites are pieces of comets or asteroids. When these pieces fall through the Earth's atmosphere, we call them **meteors**. Every day, millions of meteors enter through the Earth's atmosphere and quickly burn up. They are rarely bigger than a few centimeters. We can see meteors in the night sky, and they are known as falling stars. But they can also travel through the atmosphere and hit the ground intact—in this case, we call them **meteorites**.

So how many meteorites have actually collided with the Earth over time? The history of meteorite impacts can be found in the meteorites themselves, as well as in the craters they leave behind. This can teach us about the geologic history of the Earth and Solar System.

INTRODUCTION

In 1994, chunks of a comet called Shoemaker-Levy-9 smashed into Jupiter at over 215,740 kilometers per hour. Some of the chunks were the size of a small town. This event sent many amateur astronomers into their backyards to see the impact for themselves. It also made people wonder: had this happened before? Could it happen again, and how could we investigate it?

First, we can find and examine small meteorites. These are often preserved in deserts for millions of years. Scientists at Aix-Marseille University in France took this approach and studied meteorites from the Atacama Desert in South America.

Another method is to look at impact craters where very large meteorites have landed. Scientists at the Canadian Space Agency used this method and studied all of the impact craters that have been found on the Earth so far.

If we combine the results from these two approaches, we can learn how often meteorites have landed on Earth. This is known as the rate of impact, and it can change over time.

Many meteorites are shiny due to high levels of nickel and iron.

METHODOLOGY

Identification of Meteorites

Over 66,000 meteorites have been collected worldwide. The researchers from Aix-Marseille University selected just 54 from the Atacama Desert. When meteorites fall through the atmosphere, the outsides of the rocks melt and form a dark-colored crust. They also form other unique surface structures—including thumbprint-shaped depressions called regmaglypts. In addition, meteorites contain much higher levels of nickel and iron than Earth rocks. This can make them shiny and metallic. The researchers aged the rocks by looking at their chemical composition. This is a method for determining an object's age.

Shatter cones can be identified by their characteristic cone-shaped fractures.

Identification of Impact Craters

Meteorite impacts produce large amounts of heat and pressure that cannot be created by geologic processes. Unique metamorphic rocks are created at impact sites through a process called **impact metamorphism**.

This process creates features in rocks like **shatter cones** and **planar deformation features**. Shatter cones are fractures that form in rocks underneath a meteorite impact site. Planar deformation features look like parallel lines on a flat, glassy surface. They can only be seen under a microscope. The impact craters in the Canadian Space Agency study were identified based on these features.

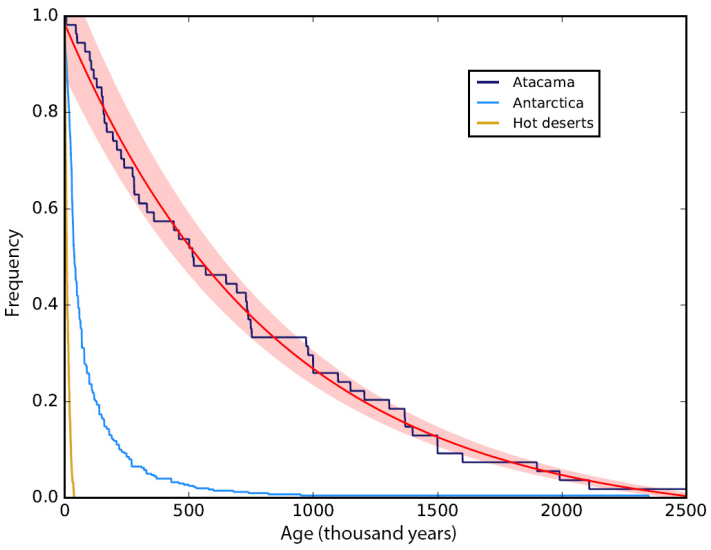
RESULTS

Evidence from Meteorites

The researchers from Aix-Marseille University measured the ages of their meteorites using **radiometric dating**. Radiometric dating is another way to figure out an object's age, and involves looking at the presence of radioactive chemicals.

This method showed that the Atacama Desert meteorites represent one of the oldest collections of meteorites on Earth. The meteorites had an average age of 710,000 years. In fact, 30 percent were over one million years old.

Age of Meteorites



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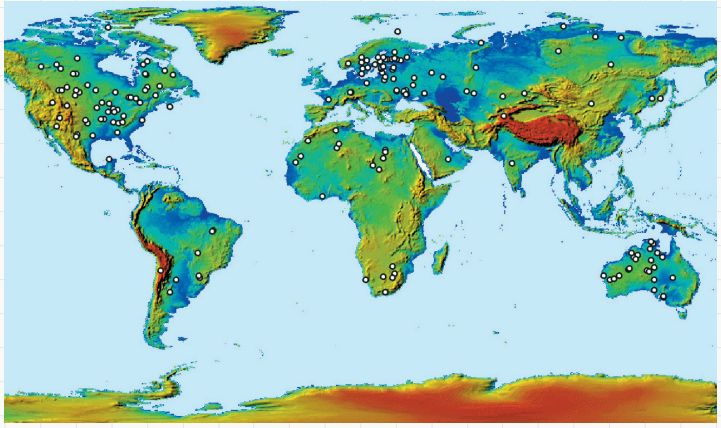
Next, they determined the meteorite impact rate by looking at how the number of meteorites changed over time. They saw a gradual decrease in the number of meteorites as the meteorite ages increased. The gradual weathering and destruction of the meteorites over centuries likely caused this decrease. This allowed the researchers to calculate that around 222 meteorites per square kilometer fall to the Earth every one million years.



Map showing the 190 meteorite impact craters that have been identified in the world

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Evidence from Impact Craters

Across the planet, 190 meteorite impact craters have been identified. About two-thirds of these were found in sedimentary rock on land, and more than half were created less than 200 million years ago. Just like with meteorites, weathering can erase evidence of craters.

The researchers at the Canadian Space Agency determined that based on the age of these impact craters, the rate of large impact events has changed over time. For example, there was an increased rate of impacts between 38–34 million years ago during the geologic period known as the Late Eocene.

CONCLUSION

In conclusion, meteorites hit the Earth at a rate of 222 meteorites per square kilometer every million years. This includes at least 190 very large meteorite impacts. By studying meteorite collisions with the Earth, we can learn about the history of the Solar System, as well as the geologic history of our planet and its future.

GLOSSARY

asteroid a rocky object that orbits the Sun, smaller than a planet but larger than a meteoroid
comet a lump of frozen gases, rock, and dust that orbits the Sun
impact metamorphism the process that creates a unique kind of metamorphic rock that only forms during a meteorite impact
meteor the visible light that is created when space debris, a comet, or an asteroid heats up as it passes through the Earth's atmosphere
meteorite a meteoroid that has passed through the Earth's atmosphere and hit the ground
meteoroid a small lump of ice or rock formed when an asteroid or comet breaks apart
shatter cone a distinctive cone-shaped structure that only forms in rock underneath a meteorite impact
planar deformation feature microscopic lines that form in the rocks of meteorite impact craters
radiometric dating the process by which the age of a fossil or rock is determined through measuring the decay of radioactive isotopes

BIBLIOGRAPHY

Drouard, A., Gattacceca, J., Hutzler, A., Rochette, P., Braucher, R., Bourlès, D., ... Martinez, R. (2019). The meteorite flux of the past 2 m.y. recorded in the Atacama Desert. Geology, 47(7), 673–676.

Earth Impact Database (2011).

French, B. M. (2004). The importance of being cratered: The new role of meteorite impact as a normal geological process. Meteoritics & Planetary Science, 39(2), 169–197.

Osinski, G. R. (2006). The Geological Record of Meteorite Impacts. Proc 1st Int Conf Impact Cratering in the Solar System, 8–12.