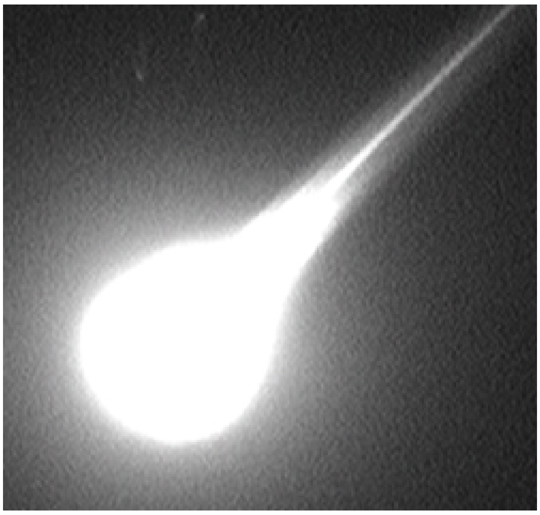
Shooting Meteorites in a Barrel

26 February 2010, by Jeremy Hsu



A Leonid meteorite imaged in 2002 from the NASA DC-8 aircraft. When meteorites enter the Earth's atmosphere, the extreme heat causes minerals and organic matter on their outer crusts to be released. This creates the familiar 'shooting star' effect. Image Credit: NASA/George Varros

High-impact lab experiments simulate whether the building blocks of life could have survived the rough arrival on Earth via meteorite impact.

Recreating how the seeds of life might have survived aboard an ancient meteorite that crashed to Earth is no small feat, but scientists have begun doing just that in their labs. Their high-impact experiments could help indicate whether life on Earth got its start from alien organic material that hitched a ride aboard space rocks.

Perhaps one of the likeliest building blocks of primordial life on Earth came in the form of amino acids, which are the basic components of proteins. And so a team of U.S. and European researchers focused on trying to replicate how well amino acids could fare when a meteorite slams into the ground.

"This study is the first which tested amino acid quantities similar to those found in real meteorites," said Marylene Bertrand, a biophysicist funded by the National Center for Scientific Research (CNRS) in France and lead author on the work published in the December issue of the journal Astrobiology.

More than 70 different amino acids have been found in meteorites that fell to Earth. Past studies have tested the survivability of many amino acids, but did not try to replicate the concentrations of organic molecules found in actual meteorites.

Bertrand's group also took the new step of testing the amino acids embedded inside saponite, a clay material found in carbonaceous chondrite meteorites that represents a possible signature of water.

ANSMET team members collect a meteorite in Antarctica during the 2006-07 field season. Field teams have sent back about 17,500 space rocks to the United States in the last 30-plus years. The meteorites contain important information about the evolution of the early solar system. Image credit: Ralph Harvey / Antarctic Search for Meteorites (ANSMET)

How to recreate a falling meteorite

Simulating a meteorite impact involved firing cylindrical plugs from a 20 mm gun at a target holding the amino acid-saponite samples in place. Researchers fired the gun inside a vacuum chamber to allow the projectiles to strike the samples at the highest possible speed, and tested a range of low to high impact pressures.

"It is easier to launch a projectile than to launch the samples," Bertrand told Astrobiology Magazine, and noted that the resulting shock from hitting the samples with a projectile was the same as if the team had shot the samples out of the gun.

The toughest amino acid survivors, including the smallest amino acid glycine, turned out to have a molecular alkyl side chain. A second group of amino acids with structures that include a functional side chain and dipeptide proved less resistant, and failed to survive the highest impact pressures.

A failure of many amino acids in the experiment to resist higher shocks seems puzzling, because many of the same amino acids appear to have survived in meteorites. Bertrand's group suggested that the samples containing the amino acids could not expand inside the metal target containers, causing them to endure higher pressures and temperatures than what they would have experienced inside falling meteorites.

Also, amino acids may have been better able to survive the shock of impact if they arrived on Earth billions of years ago, when the atmosphere was more dense and was mainly comprised nitrogen, carbon dioxide, and methane.

"The atmosphere was very different in primitive Earth and the conditions and effects of the impacts on organic matter could have been very different than now," Bertrand explained.

Amino acids also might evaporate upon impact and then eventually condense once more inside meteorites, the team noted. Or larger organic compounds could have been destroyed by the impact shock and broke apart into amino acids.

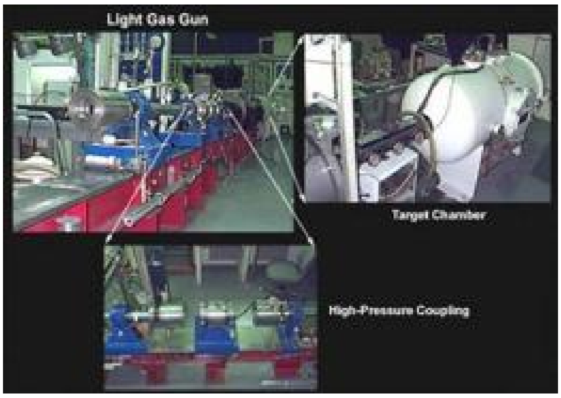
Martian meteorite ALH 84001. This 4.5 billion-year old meteorite contains microscopic structures that NASA scientists interpreted to be remnants of ancient fossilized life from Mars. Image credit: NASA

Stirring the primordial soup

Such studies raise plenty of new questions to join the unknowns already swirling around regarding how life on Earth first arose. For instance, scientists still do not know the rate of meteorites that fell at low or medium velocities, which would have made survival more likely for amino acids and other organic molecules.

Still, they know that roughly 20,000 tons of meteorites and other space particles fall to Earth each year. Any organic-bearing rocks could have made a big difference during the first 500 million years of the Earth's existence as a planet.

"I think that all organic matter present on Earth in living organisms could come from the meteorites, micrometeorites or [interplanetary dust particles]," Bertrand said. "The major question now is how the organic matter could have been processed and organized to lead to living organisms."



The scientists in this study simulated a meteorite impact by firing cylindrical plugs from a 20 mm gun at a target holding the amino acid-saponite samples in place. Image credit: Marylene Bertrand

Scientists agree that life somehow emerged from the water around four billion years ago, and also agree that such organisms mainly consisted of liquid water and organic molecules. But they still debate whether the organic building blocks arose from the sun's radiation providing energy for the early ocean "soup," or whether undersea hydrothermal vents provided the necessary biochemistry touch.

If meteorites provided a third way by bringing life's ingredients to Earth, then their precious organic cargo must have somehow survived an even more daunting prospect than impact — the long journey through space.

Bertrand's group also wants to check out the effects of space conditions on organic molecules. They have already conducted experiments that exposed amino acids to ultraviolet light in the harsh vacuum outside the International Space Station, as well as in lab settings on Earth.

Source: Astrobio.net