Is There Water - And Life - On Mars?

"Although life at the Martian surface would have been possible only 3.5 or 4 billion years ago, life could have existed on Mars any time from 4 billion years ago all the way up to the present. And if it does exist, it would be below the surface. "

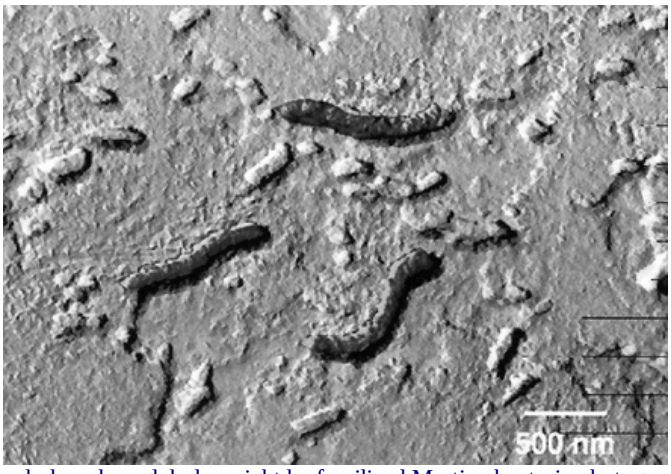
- Bruce Jakowsky, Ph.D., Geologist and Planetary Scientist,
University of Colorado, Boulder

December 2, 1999 Houston, Texas - On Friday, December 3rd, NASA's Polar Lander will set down on the South Polar Cap of Mars. Two probes designed to punch into the soil will be released. If all goes well, soil samples will be warmed up and analyzed for water. If there's ice, there might be liquid water underground. And if there's water, then life could still possibly exist on Mars - even if only bacteria and other microbes below the surface.

The Allan Hills, Antarctica ALH84001 meteorite discovered in 1984 that made worldwide headlines because scientists found rice-shaped carbon globules in tiny cracks on the rock which
resembled earth bacteria. The carbon in this meteorite dates back about three billion years when
Mars probably had water on its surface, was warmer and had a global magnetic field.
Photograph provided by the NASA Johnson Space Center, Houston, Texas.

Scientists still argue about the meteorite found at Allan Hills, Antarctica in which fossilized bacteria was reported on August 8, 1996. One of the scientists who has studied the Allan Hills meteorite is biochemist and Senior Researcher Kathie Thomas-Keprta at the Johnson Space Center in Houston. Her work began there fifteen years ago analyzing microscopic carbon particles in meteorites. Then she switched her attention to the unusual globules on the Allan Hills meteorite and was co-author on the first paper published in Science that set off the media firestorm of headlines about fossilized bacteria from Mars. Now she has stronger evidence that links the Martian meteorite to living microbes: tiny strings of hexagonal-shaped crystals of magnetite found inside the

fossilized globules in the Martian rock.



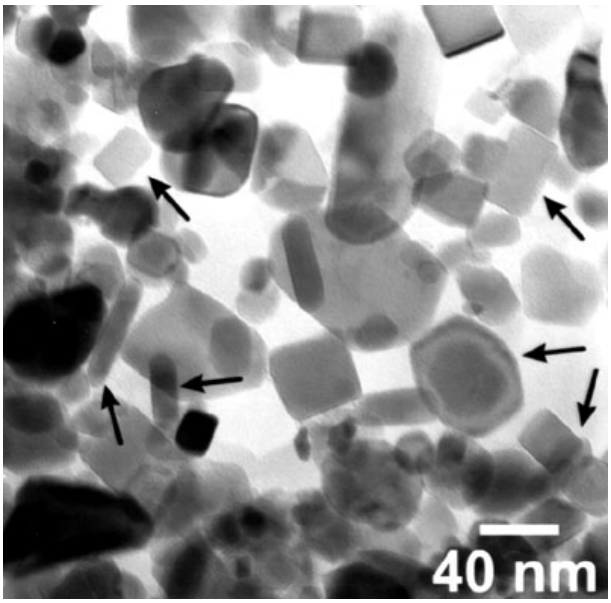
These three dark carbon globules might be fossilized Martian bacteria photographed in the Allan Hills, Antarctica meteorite by Kathie Thomas-Keprta at the NASA Johnson Space Center,
Houston, Texas. Small magnetite crystals were discovered inside the globules.

Interview:

Kathie Thomas-Keprta, M. S., Biochemistry, Senior Scientist, NASA Johnson Space Center, Houston, Texas: "Really the simplest thing about the magnetite is that we know that there is no question that these magnetite grains we find in the carbonates in Allan Hills formed on Mars. There is no question of that.

WE KNOW THAT BECAUSE?
We know that because the carbonates formed on Mars based on their oxygen and their carbon isotopic analyses. These magnetites are sitting in carbonate. And if you can envision a pancake and these magnetites are sitting on the top surface of the carbonate and they are distributed all the way through the carbonate. So, we know that if the carbonate formed on Mars, then the magnetite formed on Mars. And we're definitely able to say the carbonate formed on Mars. So, now we know that the magnetite formed on Mars.

CAN YOU PLEASE EXPLAIN FOR A GENERAL RADIO AUDIENCE WHY THE MAGNETITE ITSELF MIGHT BE AN EVIDENTIARY LINK TO THE MATERIAL IN THIS METEORITE ACTUALLY RELATED TO BACTERIA?
All right. We see three general types of magnetite associated with the carbonates in the Allen Hills meteorite. And the third type makes up about 25% of all of the magnetite in Allen Hills in the carbonate globules. And these types of, these forms, these shapes of these magnetites have a very distinctive shape. They look like if you can envision little hexagonal columns. We've scoured the literature. We've looked at a lot of magnetite ourselves. And what we've found is that the only way we know how to produce magnetites with this type of shape and in a very tiny size range that we call a 'single domain size range,' is by bacteria here on earth. We don't know any other way to produce those types of magnetites. And we're seeing exactly the same types of magnetites in the Allen Hills meteorite.



Transmission electron microscopy of hexagonal-shaped magnetite crystals found inside the carbon globules on the Allan Hills, Antarctica meteorite from Mars that might be fossilized bacteria. Image photographed by Kathie Thomas-Keprta at the NASA Johnson Space Center, Houston, Texas.

WHAT PRODUCES THE HEXAGONAL STRUCTURE IN EARTH'S BACTERIA?

Well, there are certain types of bacteria on earth that are called magnetotactic bacteria. And initially, they weren't discovered until 1975. So, they've only been around, we've only known about them for about 25 or 30 years now. And these organisms if you can envision them as long rod-shaped organisms and inside the organisms they produce almost what you would call a chain of pearls and they look, they are actually a chain of magnetite.

WHY WOULD BACTERIA HAVE PEARL-LIKE CHAINS OF MAGNETITE THAT HAS THIS ODD HEXAGONAL SHAPE?

Well, it's interesting because these organisms use these magnetites and what they do is use these magnetic chains to orient themselves in the earth's magnetic field. And it was determined by Mars Global Surveyor and work that was done by Akuna and published in *Science* I think it was in 1998 that indeed it looks like at one time Mars had a very strong global magnetic field.

DO THEY KNOW HOW FAR BACK YOU HAVE TO GO TO THAT POINT?

The age of these carbonates, in recent work that has been done by Nyquist and Borg and recently published in *Science* here just maybe a month or two months ago, they found that the age of the carbonates runs around 3.92 billion years of age. So, that would mean that indeed as these magnetites became incorporated into the carbonate and these organisms died that at that time Mars would have had a strong magnetic field.

WHY WOULD MARS HAVE HAD A STRONG MAGNETIC FIELD AND THEN LOSE IT?

We don't understand that. Why would Mars have had water on the surface of the planet at one time and have lost that as well? We believe that Mars and Earth formed under very similar circumstances that the planets in the early evolution, both planets followed a very similar pathway. But we're not sure what happened to Mars."

Why Did Mars Lose Both Its Surface Water and Magnetic Field?

ANOTHER SCIENTIST WHO WOULD ALSO LIKE TO UNDERSTAND

MARS' CLIMATE AND WATER HISTORY AND POTENTIAL FOR LIFE IS DR. BRUCE JAKOSKY, PROFESSOR OF GEOLOGIC AND PLANETARY SCIENCES AT THE UNIVERSITY OF COLORADO IN BOULDER. HE WORKS IN THE LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS. I ASKED DR. JAKOSKY WHAT MIGHT HAVE CAUSED MARS TO LOSE BOTH ITS SURFACE WATER AND MAGNETIC FIELD?

Bruce Jakosky, Ph.D., Professor of Geologic and Planetary Sciences at the University of Colorado in the Laboratory for Atmospheric and Space Physics (LASP), Boulder, Colorado:
"That's the $64,000 question. The CO2 that would have produced a greenhouse atmosphere could have been lost to space. It could have been incorporated into the ground as carbonate minerals, and once that happens, the water could have frozen out in the ground. It might have been lost to space as well. I think that's one of the goals of this next decade aside from the life question to try to understand happened to the climate? What happened to the geology? What has the history of Mars been?

COULD IT HAVE BEEN FROM AN IMPACT BY A COMET OR A LARGE METEORITE?
No, not alone.

WHAT WOULD HAVE PRECIPITATED THE LOSS OF ATMOSPHERE AND WATER?
One possibility is that the turn off of the magnetic field 3.5 billion years ago allowed a mechanism of solar wind stripping of the atmosphere to turn on and that could have been the precipitating mechanism.

BUT WHAT WOULD HAVE LOST THE MAGNETIC FIELD ON MARS?
The planet cooling down. It's a small planet. It's getting colder losing its heat through time.

BECAUSE THE MOLTEN CORE WOULD HAVE GONE INTO A FROZEN STATE?
Yes. Exactly. Based on our current understanding of what it takes to support life, there's no reason to think that life on Mars if it ever existed ceased when the surface became cold and dry. On earth we see examples of micro-organisms that can live beneath the surface of the earth. For example, getting their energy from chemical reactions between water and rock miles below the surface. There is every reason to think those same times of environments would be present on Mars - that liquid water is present beneath the surface and that there are environments on Mars that could easily support these types of organisms. So, although life at the Martian surface would have been possible only 3.5 or 4 billion years ago, life could have existed on Mars any time from 4 billion years ago all the way up to the present. If it does exist, it would be below the surface.

The Mars Polar Lander does not have any life detection experiments on it. It's a climate space craft. The goal of the mission is to try to understand the behavior of water. Water, of course, is a key ingredient in understanding the conditions as to whether life could exist or not. But by looking at the water, measuring water vapor in the atmosphere, the properties of the atmosphere, digging down and looking for ice in the ground. What we're really doing is trying to understand how the seasonal cycles work and what the integrated effect is over timescales up to a million or ten million years. If we can understand that, we can begin to address questions like how much water is there on Mars today? Where is the water? How does it move around? Does it cycle between the polar caps, the atmosphere and the ground? And how much moves around?

THERE STILL MIGHT BE MAGNETITE-BEARING BACTERIA IN MARTIAN SOILS?
That's right. We don't know, based on our current knowledge, whether we have found fossil evidence of Martian life. I think the one thing that people are

becoming convinced of is we're not going to get the answer from the rocks we have today. The meteorites that have come from Mars are just too complicated and we don't know where on Mars they came from. If we're going to answer the question about life, most people are recognizing that we need to go back to Mars, go to places where liquid water has existed where life had the best opportunity to exist, land on the surface, collect rocks that have had the best opportunity to retain some memory of that life from a long time ago, bring those rocks back to earth and study them in detail here.

THAT'S SUPPOSED TO START OCCURING IF ALL GOES WELL IN THE 2003 AND 2005 MISSIONS TO ACTUALLY BRING SAMPLES BACK TO THE EARTH BY 2008?
That's right.

DO YOU KNOW HOW THEY PLAN TO GET THE LANDERS BACK UP INTO ORBIT AROUND MARS AND BACK TO EARTH?
They are not going to bring the entire lander back. What they are going to do is collect the samples and put them in a small sample container about the size of a small volley ball and launch that into orbit on a tiny rocket. Once it's in orbit, a separate spacecraft will collect the sample containers and bring them back to the earth.

DOING ALL OF THIS UNMANNED?
Yes.

IT'S QUITE A FEAT.
It's not a trivial task. It challenges us in the same way that the Apollo program putting humans on the moon challenged us 30 years ago. Meaning it's not obvious we're going to succeed. Not the first time."

Website:

http://www.jpl.nasa.gov

Credits