A salty, martian meteorite offers clues to habitability

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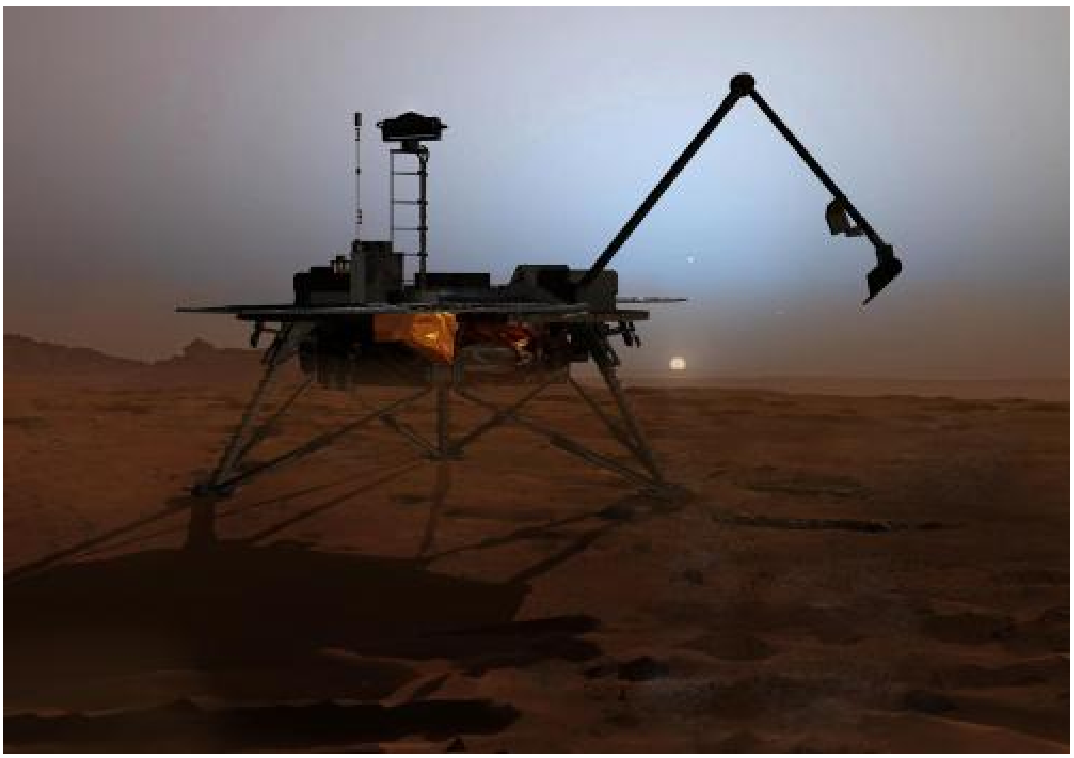


Artist’s conception of the Mars Phoenix lander, which found perchlorate on the Red Planet in 2008. Credit: NASA/JPL-Caltech

Life as we know it requires energy of some sort to survive and thrive. For plants, that source of energy is the Sun. But there are some microbes that can survive using energy from chemical reactions. Some of them even eat salts, such as perchlorates.

Perchlorate (ClO_4^-) is a highly oxidized form of chlorine. Perchlorate salts are found not only on Earth, but also on Mars. They're highly toxic to humans but are useful for components such as rocket fuel.

It was good news for future Martian explorers when in 2008 an instrument on the Mars Phoenix polar lander discovered evidence of perchlorate in a flat valley informally called "Green Valley." Four years later, the new NASA Curiosity rover uncovered more of the substance near the equator.

Now, there's stronger evidence that the salt is widespread. New research shows that a martian meteorite recovered on Earth has perchlorate in it as well as other salts, namely chlorate and nitrate.

"We analyzed it and didn't know what to expect," said lead author Samuel Kounaves, a chemistry professor at Tufts University in Massachusetts. "We found perchlorate, not so high as on Mars, but at a well detectable level."

Learning about salts on Mars also leads to related questions about organic materials and habitability on the Red Planet in general. While it's a harsh environment for microbes today, it's possible that they could survive in protected areas (such as underground), or that they were there in the past when climate conditions may have been warmer and wetter.

The results of the study, called "Evidence of martian perchlorate, chlorate, and nitrate in Mars meteorite EETA79001: Implications for oxidants and organics," was recently published in the journal Icarus.

Checking for contamination

Kounaves led the Phoenix team that discovered perchlorate on Mars, so he is familiar with what the substance looks like on the Red Planet. With this new discovery, his team took pains to make sure that this meteorite was not contaminated in any way from the surrounding environment.

"We said that if this is terrestrial contamination it should match the material where the meteorite was found in Antarctica," Kounaves said.

The team used samples from a meteorite that was recovered in Antarctica during the 1979 field season. It is estimated to be 170 million years old (give or take 20 million years), was ejected from Mars about 65 million years ago, and is believed to have arrived on Earth roughly 12,000 years ago.

Researchers are sure the meteorite came from Mars because of the noble gases trapped inside of it, which are generally nonreactive gases such as helium, neon and argon. These gases have been analyzed on Earth, Mars and Venus in past missions and the match was closest to that of Mars.

Scoop marks made by the Mars Science Laboratory Curiosity rover at a site called "Rocksnest" in 2012. After analyzing the sample inside the rover, scientists found a compound with chlorine and oxygen that likely is from chlorate or perchlorate. Credit: NASA/JPL-Caltech/MSSS

To check for contamination, Kounaves' group examined the ratios of types (isotopes) of nitrogen and oxygen, and discovered that the isotope ratios were different in the meteorite than in the ice where it was recovered, or in the nearby Antarctic Dry Valley soils. Similar results were also found for the ratios of chlorate and perchlorate to nitrate.

The perchlorate and other salts Kounaves was interested in was embedded in the very center of the 17 pound meteorite, three inches from the closest surface.

"It's hard to believe that in the short period of time it laid in the ice in Antarctica it would have picked up that much perchlorate, nitrate and chlorate," he said.

Looking for life

The presence of perchlorate on Mars has some astrobiological implications. On Earth, perchlorate is typically used for making fuel, explosives and matches, but it is a health hazard to humans. Terrestrial microbes, however, can use it as a source of energy.

Perchlorate can also lower the freezing point of water to approximately -70 degrees Celsius (-94 degrees Fahrenheit.) On the cold Martian surface, where water exists in frozen polar ice caps and in frost, perchlorate makes it possible to keep water as a liquid. Microbes, however, could have a tough time living in such a brine because it lowers the availability of water molecules for life, Kounaves cautioned, similar to how ocean salts are harsh for certain types of organisms.

Concentrations of perchlorate on Mars are only about 1 percent, too low to be easily detected by any instruments on orbiting spacecraft, such as NASA's Mars Reconnaissance Orbiter. That said, there are features on the Red Planet that are visible from orbit, such as gullies, that suggest flowing water. There are other explanations as well for these features, however, such as frozen carbon dioxide.

The links between perchlorate and water and life are not a given, but Kounaves said examining the relationship helps him better understand the potential for life on Mars. Figuring out the boundaries of habitability helps answer that question.

Mars is a harsh environment. It is very cold and dry. The surface is baked by radiation, and disturbed by occasional global dust storms. For microbial life to survive under such extreme conditions is highly improbable, but Kounaves said that life may find protection deep underground, and the search for life should, perhaps, begin there.

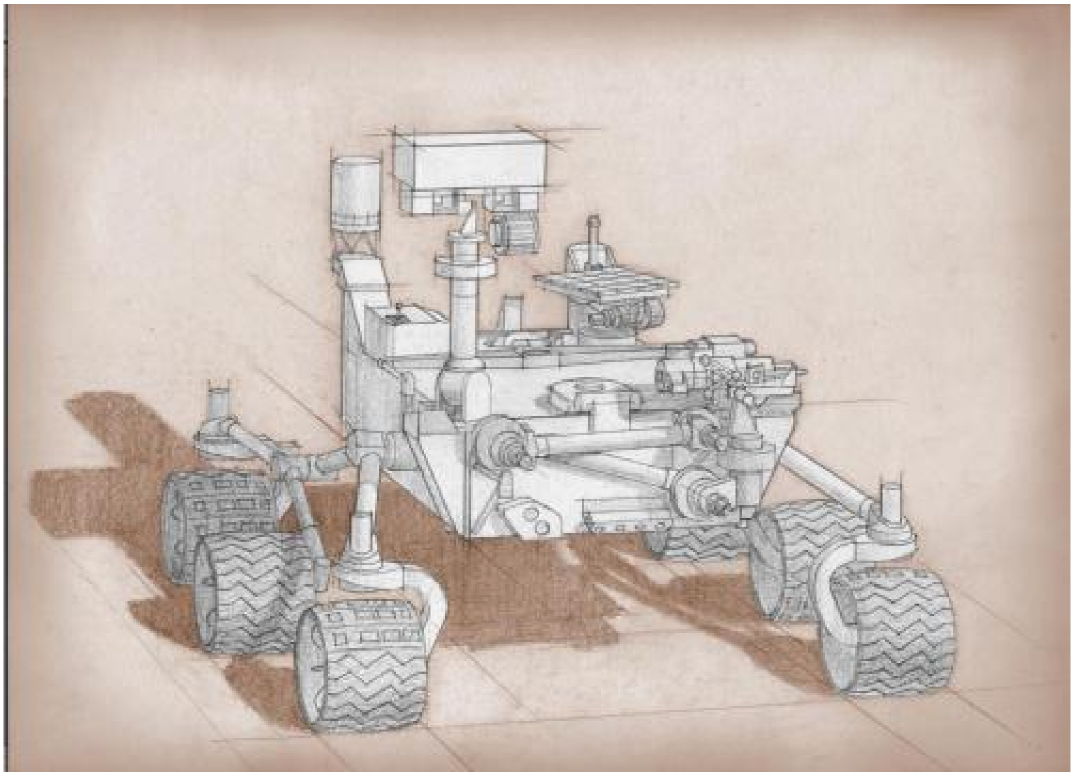
"It's possible that if you go deep enough—maybe a kilometer underground, who knows how deep—there may be areas on Mars that may have allowed life to survive after having emerged billions of years ago." he said.

This meteorite, EETA79001, a basalt lava rock nearly indistinguishable from many Earth rocks, provided the first strong proof that meteorites could come from Mars. Originally weighing nearly 8 kilograms (17.6 pounds), it was collected in 1979 in the Elephant Moraine area of Antarctica. Credit: NASA/JSC/JPL/Lunar Planetary Institute

Looking for organics

A related question to searching for salts on Mars is finding organic materials. Searching for organics has been a point of contention over the years, particularly with regard to some famous experiments on NASA's Viking 1 and 2 landers in the 1970s.

At first blush, the Viking experiments seemed to show evidence of life. A gas exchanger detected oxygen from a sample of Mars soil that was treated with organic and inorganic compounds. Another experiment with Earth organic compounds inside Mars soil showed evidence of carbon dioxide, and another experiment detected organic residues in a sample of heated Mars soil.



Artist's conception of the Mars 2020 rover, which will include instruments to search for organic materials on the Red Planet. Credit: NASA/JPL-Caltech

Critics, however, pointed out that microbes don't necessarily release oxygen and it was unclear if the organic compounds that were detected were, indeed, from Mars.

The Curiosity rover did find organics while heating up a portion of martian soil, but it was unclear if those organics were due to terrestrial contamination, as NASA acknowledged in results released in December 2012. The only thing that was clearly martian in this sample was evidence of water, sulphur and substances containing chlorine.

"We have no definitive detection of martian organics at this point, but we will keep looking in the diverse environments of Gale Crater," said

NASA Goddard's Paul Mahaffy, the principal investigator of the Curiosity instrument that found the results at that time.

Tracks from the Mars Science Laboratory Curiosity rover after crossing a dune on the Red Planet. Scientists are interested in learning what resources are available on the Red Planet for possible fuel sources, among other things. Credit: NASA/JPL-Caltech/MSSS

However, it's also possible that the act of heating up or altering the soil could destroy any organics that would have been present in the first place, and that's leaving aside the question of how radiation would damage organics on the surface.

"Maybe it's in rocks, ancient rocks, where the organics may be protected," Kounaves added.

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