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Astrobiology

Organic mineral bonanza on Mars

NASA's Curiosity rover has found more potential signs of ancient life

Alex Wilkins

MORE signs of the organic molecules that could have helped sustain life have come to light on Mars. The molecules were well-preserved in the clay minerals of Gale crater, a 155-kilometre-wide suspected former lake.

These sulphur-bearing organics were found in the Glen Torridon region of the crater, which the Curiosity rover explored from 2019 to 2021. Kristen Bennett at the US Geological Survey Astrogeology Science Center in Arizona and her colleagues presented the findings at the Lunar and Planetary Science Conference in Texas on 9 March.

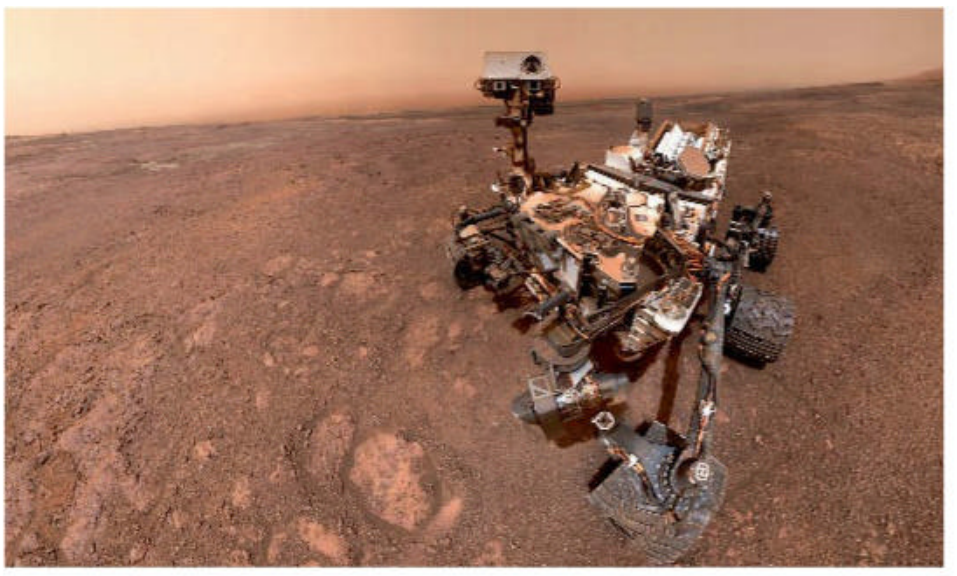
"We identified the most clay minerals in a sample thus far observed in the mission and we observed the most organics," says Bennett. "It really showed that [Gale crater] was this habitable ancient environment with high organic preservation potential."

Curiosity collected and analysed 10 samples from Glen Torridon by drilling into the Martian rock and then heating the extracted material to determine its chemistry using an on-board sample-analysis machine.

While organic molecules have been found in Gale crater before, the Glen Torridon region presented the greatest abundance. They also included several molecules that can be found on Earth associated with biological processes.

Scientists are now trying to identify the point of origin of these molecules. While they could indicate biological processes – for instance, they can be produced by heating coal or through the activity of bacteria that metabolise energy from sulphur – it is more likely that they are the product of non-biological processes such as impacting meteorites or volcanic activity.

NASA's Curiosity rover landed on Mars in August 2012



NASA/JPL-CALTECH/MSSS

"It's going to take years before we can actually constrain, and maybe we never will, where this organic matter is coming from," says Maëva Millan at Versailles Saint-Quentin-en-Yvelines University, France, who is part of the team analysing these sulphur-bearing compounds.

There are several ingredients that go into a life-supporting environment in addition to sulphur organics, such as the presence of water with a neutral pH and temperatures similar to those found on Earth's surface. Many of these important preconditions for life as we know it have been found over the course of Curiosity's time in Gale crater. But the clay minerals are of particular significance, because they can both preserve evidence of organic matter and serve as evidence itself of previously habitable conditions.

"Clay minerals are an important marker for planetary scientists, because they require water to form," says Bennett.

"If the original goal of the Curiosity rover was to identify habitable environments, and water is a key indicator of a habitable environment, it follows that clay minerals that are water indicators are a good way to go about that," she says. ▮

Physics

The slow speed of sound on Mars has been measured

NASA's Perseverance rover has used its microphones to give us our first ever measurement of the speed of sound on Mars.

Baptiste Chide at Los Alamos National Laboratory in New Mexico and his colleagues recorded sounds from Mars's Jezero crater last year, such as the rover's laser striking rocks, which generates a shock wave. They also captured the frequency shift of the Ingenuity helicopter's blades as it moved through Mars's atmosphere after launching from Perseverance.

The laser and microphone aboard Perseverance were precisely synchronised, allowing the team to use these recordings to calculate the speed of sound on Mars. It is about 240 metres per second, slower than the 340 metres per second at which sound travels on Earth.

The sound of speed on Mars also varied over small distances, which the researchers used to infer characteristics about the planet's atmosphere, such as temperature over small scales, which hadn't been previously measured.

"We have a response time with acoustic measurements that is way faster than what we can achieve with standard and classical air temperature sensors," says Chide.

The work, which was presented at the Lunar and Planetary Science Conference in Texas on 8 March, also revealed that sound travels in an unusual way in the Martian atmosphere, which is primarily low-pressure carbon dioxide. Higher frequency sounds arrive before the lower ones due to the way CO_2 molecules vibrate at low and high frequencies.

"You would receive the low and high frequencies separately, leading to a kind of distortion"

"You would receive all the low frequencies of my voice a few milliseconds after the high frequencies... so it would lead to a kind of distortion of sounds that would be quite difficult to understand," says Chide.

The rover recorded more than 5 hours of sound, which people are still analysing to learn how the atmosphere and temperature change with Martian seasons. ▮ AW

Astrophysics

Moon's emergence from planet crash reconstructed

Alex Wilkins

COMPUTER simulations that trace how our moon formed in high resolution may explain the mystery of why it is so chemically similar to Earth.

The conventional story for the moon's origin is that a primordial planet named Theia smashed into Earth and spewed molten rock into space. This debris, primarily made up of Theia, then coalesced into the moon over a period of tens of millions of years.

While this scenario accounts for the moon's observed angular momentum, it fails to explain the near-identical profile of its isotopes to those found on Earth. Isotopes are atoms of the same element that differ by the amount of neutrons they contain, and the ratio of different isotopes in a sample can be used to trace its origin.

Jacob Kegerreis at Durham University in the UK and his colleagues ran more than 400 high-resolution simulations of what might have happened when the early Earth was struck, using different initial conditions like impact angle and speed.

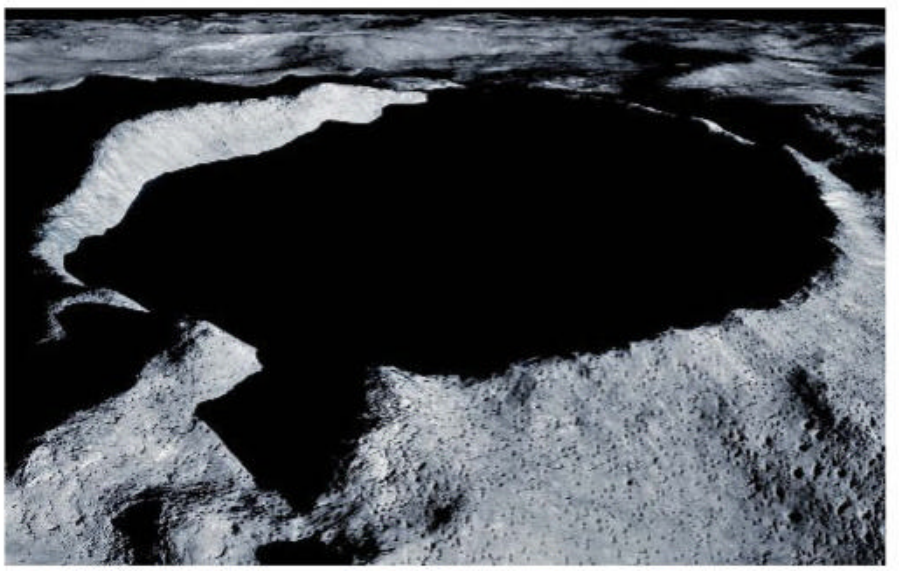
Many of the simulations showed a satellite forming within hours of the impact – much more quickly than suggested by previous research. They produced a moon with a similar angular momentum and isotopic make-up to Earth, which means that the moon contains more of Earth and less of Theia than other models supposed. The findings were presented at the Lunar and Planetary Science Conference in Texas on 10 March.

"It's interesting that simulations in this work lead to more mixing between the impactor and proto-Earth than previous work suggested," says Miki Nakajima at the University of Rochester in New York. "This would help explain the isotopic similarities between Earth and the moon." ▮

Astronomy

Double-shadowed craters could hold ice on the moon

Jonathan O'Callaghan



JORGE MAÑES RUBIO/ESA/ACT/DITISHOE

Shackleton crater sits at the moon's south pole

SOME of the moon's craters may contain "double-shadowed" regions that are so dark they would be among the coldest places in the solar system.

The small tilt of the moon – just 1.5 degrees – as it orbits with Earth around the sun means that it has hundreds of craters where direct sunlight never reaches. We know that inside these craters, located near the moon's poles, temperatures can drop below -170°C, making them prime locations for water ice to collect and optimum locations for future human missions, as astronauts could use the ice as a source of water for their missions.

Even though the insides of these craters don't receive direct sunlight, they can be heated by sunlight reflecting off their rims, which can melt some of their more exotic ices, such as carbon dioxide ice.

Now, Patrick O'Brien and Shane Byrne at the University of Arizona in Tucson think they have found even darker craters that are shielded from this reflected sunlight. These double-shadowed regions would be rare, a fraction of a per cent of the total area of craters that don't receive direct sunlight, with temperatures dropping to -250°C.

"Their main source of light is starlight," says O'Brien, who presented the work at the Lunar and Planetary Science Conference in Texas on 7 March. "They could be the coldest places in the solar system."

Evidence for these frigid craters comes from NASA's Lunar Reconnaissance Orbiter,

-250°C

Temperature in lunar craters that see no reflected light

which uses a laser to study the moon's surface. Billions of pulses have been fired at the moon for more than a decade, says O'Brien, allowing detailed measurements of the lunar surface to be made. The team used this information to search for and examine these double-shadowed craters.

"They've been predicted, but we're the first to actually look for them on the moon," he says.

For a double-shadowed crater to exist, it must be sufficiently deep and set at an angle that wouldn't allow sunlight to be reflected in. In total, the researchers found hundreds of suitable craters that could host double-shadowed regions, ranging in size from 100 to 600 metres across, but the team says there could be many more smaller ones, with diameters of just tens of centimetres.

Margaret Landis at the University of Colorado Boulder, who wasn't involved in the research, says these colder regions could help us work out where water ice or other exotic ices on the moon and other bodies came from.

Temperatures of -170°C "are great to preserve water ice, but too warm for other ices like carbon dioxide, or organic species that might be a fingerprint of a comet impact", she says. Such impacts could have been a source of Earth's water.

"It has massive implications for the amount of water that Earth got from non-Earth sources," says Landis.

An upcoming NASA lunar rover may be able to drive into some of these regions. Called VIPER, it is scheduled to arrive at the moon's south pole in November 2023 and will drive for up to 10 hours at a time into three regions that never receive direct sunlight. It will use a drill and headlights to look for ice, and it may also discover some of these double-shadowed craters.

"One of our objectives is to locate and observe multi-shadowed craters," says Anthony Colaprete at NASA's Ames Research Center, the VIPER mission's lead scientist. "It's going to be pretty awesome." ▮