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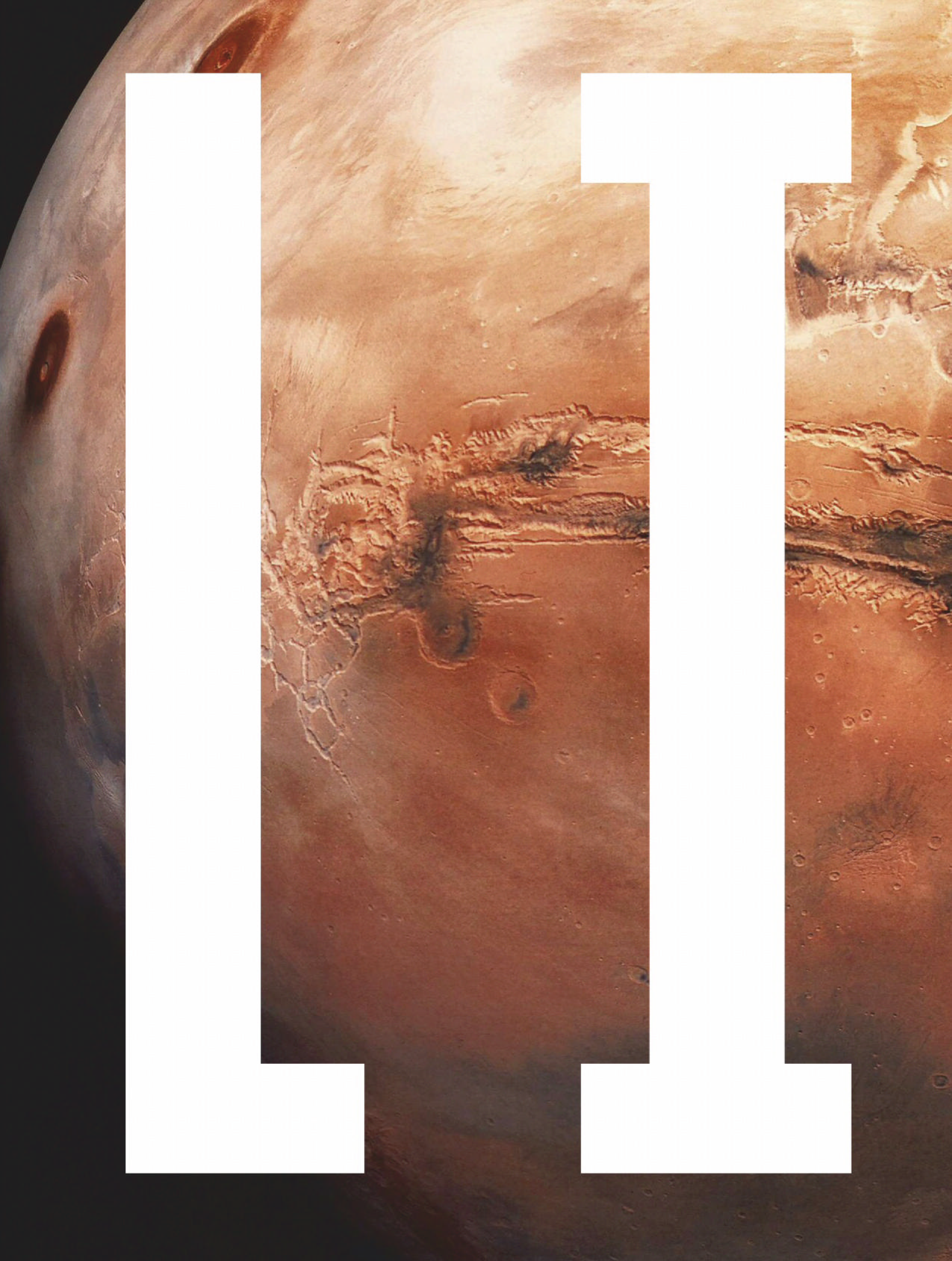
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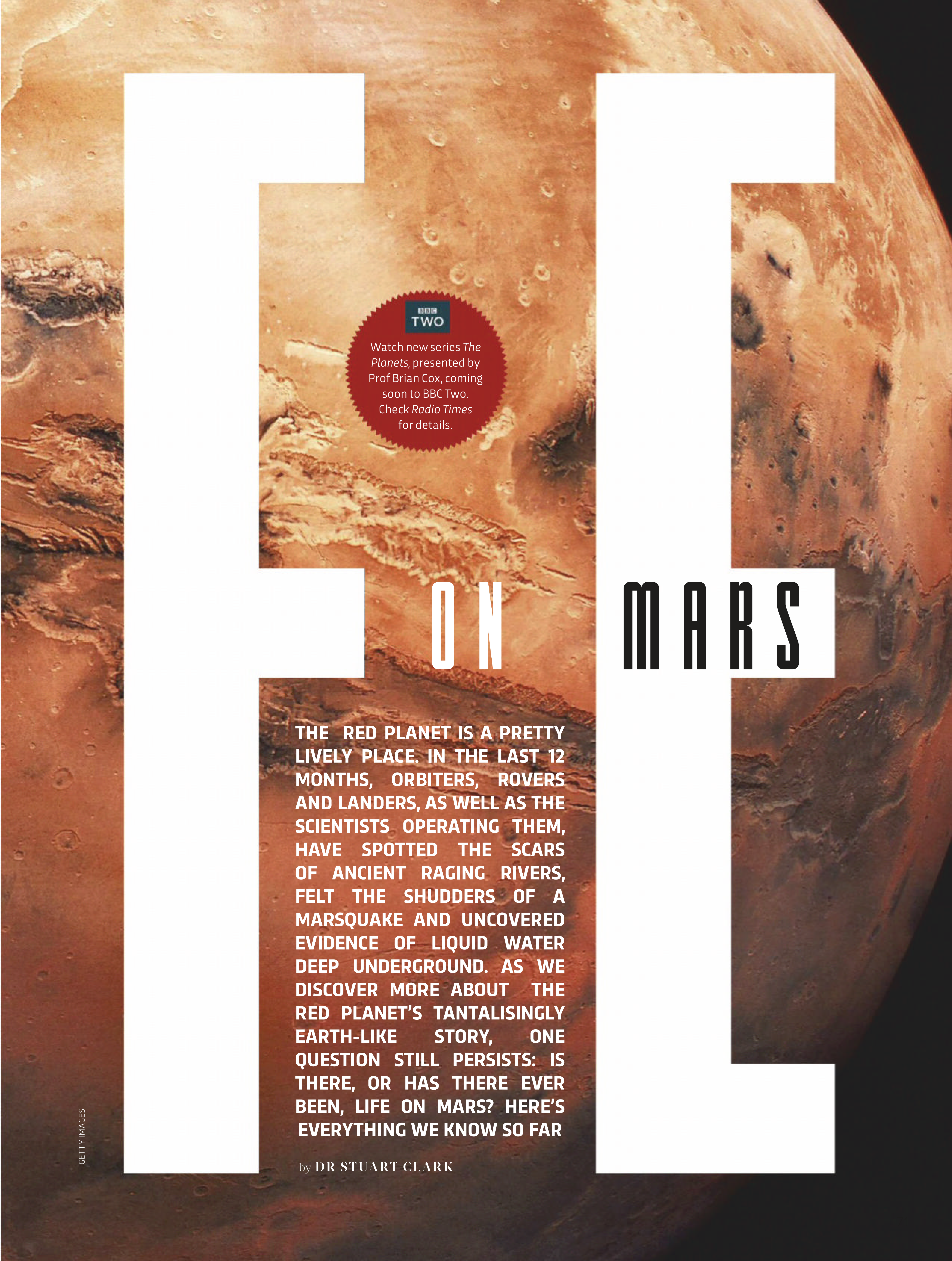

ON MARS

BBC TWO

Watch new series *The Planets*, presented by Prof Brian Cox, coming soon to BBC Two. Check *Radio Times* for details.

THE RED PLANET IS A PRETTY LIVELY PLACE. IN THE LAST 12 MONTHS, ORBITERS, ROVERS AND LANDERS, AS WELL AS THE SCIENTISTS OPERATING THEM, HAVE SPOTTED THE SCARS OF ANCIENT RAGING RIVERS, FELT THE SHUDDERS OF A MARSQUAKE AND UNCOVERED EVIDENCE OF LIQUID WATER DEEP UNDERGROUND. AS WE DISCOVER MORE ABOUT THE RED PLANET'S TANTALISINGLY EARTH-LIKE STORY, ONE QUESTION STILL PERSISTS: IS THERE, OR HAS THERE EVER BEEN, LIFE ON MARS? HERE'S EVERYTHING WE KNOW SO FAR

by DR STUART CLARK

GETTY IMAGES

A GASSY ENIGMA

ARE MARTIAN MICROBES BELCHING GAS INTO THE PLANET'S ATMOSPHERE?

In March 2004, ESA's Mars Express mission confirmed that methane gas was present in the Martian atmosphere. The amount of methane was small but its discovery was extraordinary because on Earth, although some methane in the atmosphere comes from volcanoes, most of it is produced by living organisms.

Methane only survives in the Martian atmosphere for a few hundred years, meaning that whatever was producing it was (geologically speaking) recent. Although the volcanic explanation would be fascinating because Mars was thought to be geologically dead, the biological origin is what grabbed people's attention.

The methane seen by Mars Express was concentrated in certain regions and quickly dispersed to levels that could no longer be detected. Then, a decade later, the methane returned.

This time it was detected by NASA's Mars Curiosity rover, which had landed in Gale Crater in 2012. Using its onboard Sample Analysis at Mars (SAM) instrument suite, the rover took a dozen readings over a 20-month period, mostly revealing extremely low levels of the gas. However, in late 2013 and early 2014, methane levels rose sharply by a factor of 10.

"At this point we don't know the origin of this methane," said NASA's Danny Glavin, a participating scientist in the Curiosity mission, at the time. The same remains true to this day.

Most recently, a re-analysis of Mars Express data has shown that it too detected methane in Gale Crater in June 2013. However, ESA's follow-on mission to look specifically for methane, the Trace Gas Orbiter, has not yet seen any traces at all, despite looking with sensitivities between 10 and 100 times higher than the previous positive detections.

In 2020, the second part of the ExoMars mission, containing a lander and rover, will arrive at Mars and continue the search. "The Rosalind Franklin rover itself won't look specifically for atmospheric methane [but] the ExoMars landing module, named Kazachok, will have several different atmospheric spectrometers on board, so these will also investigate the local chemical composition of the Martian atmosphere," said Abbie Hutty, ExoMars delivery manager and structure supplier operations manager at Airbus Defence and Space.

1 Snapshot of Mars's south pole, taken by ExoMars's Trace Gas Orbiter

2 The Mars Curiosity rover detected methane at Gale Crater, as photographed here

3 The intrepid rover collecting soil samples from the surface of Mars

NASA X2, SCIENCE PHOTO LIBRARY


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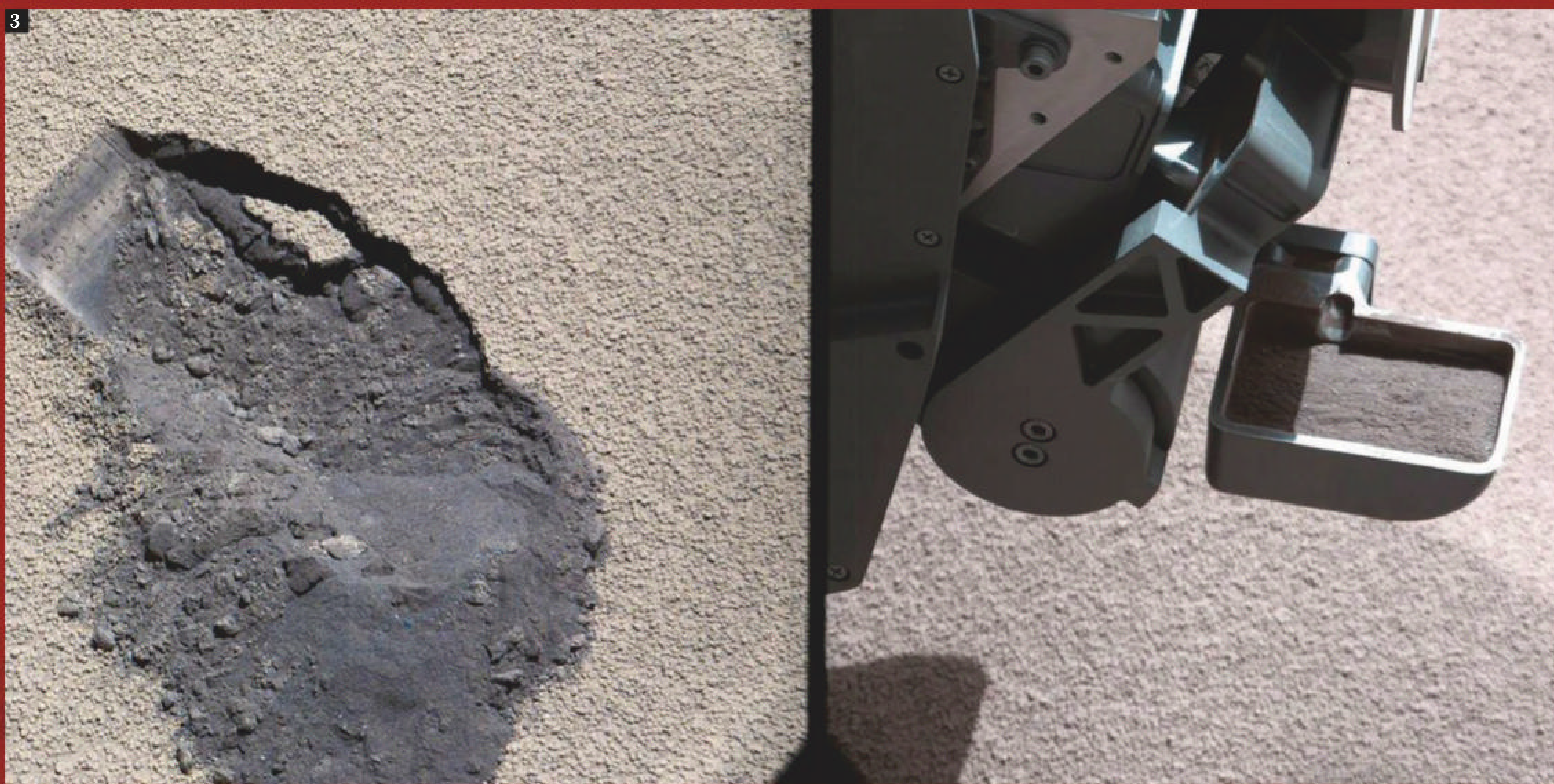


SAMPLE RETURN

THE ONLY WAY TO BE CERTAIN IS TO BRING SOMETHING BACK

In the search for life on Mars, many researchers believe that there is only one way to make real progress: bring Mars rocks back to Earth. According to Prof Monica Grady, a planetary and space scientist at The Open University, the "plan to bring back rocks from Mars is our best bet for finding clues to past life." Last year, ESA and NASA signed a memorandum of understanding that pledges the agencies to work together to design a series of missions that will bring Mars rocks back to Earth. "Returning Martian samples is a huge challenge that will require multiple missions, each one successively more complex than the one before," said David Parker, ESA's director of human and robotic exploration. NASA's 2020 rover will be a step towards sample return because it will cache interesting samples in up to 31 canisters that will be left on the Martian surface. A second mission would then retrieve those canisters and place them in a Martian ascent vehicle, which would boost them into orbit. A third mission from Earth would rendezvous with this vehicle in Mars orbit and bring it back to Earth. "A Mars sample return mission is a tantalising but achievable vision that lies at the intersection of many good reasons to explore space," says Parker.

European science ministers will meet later this year to decide whether to fund the necessary sample return missions.

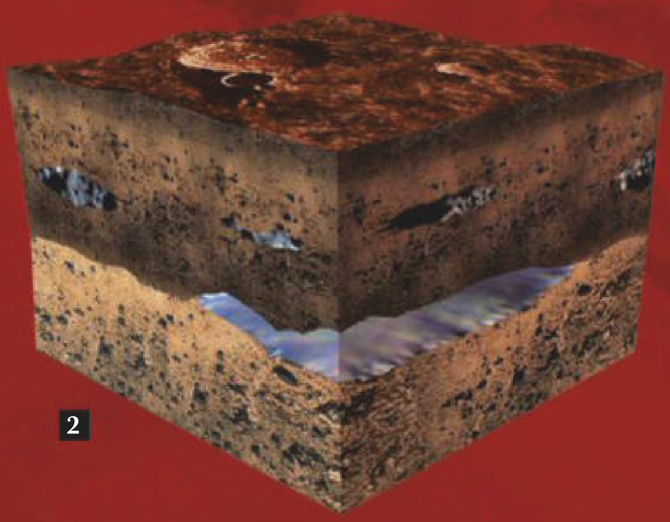
MAKING A SPLASH ON THE RED PLANET

LIQUID WATER IS LURKING BENEATH MARS'S SURFACE. HERE'S HOW WE'LL STUDY IT

Planetary geologists have long wondered what happened to the Martian water. Either it escaped into space or it seeped into the ground. If it's in the ground then there should be great underground lakes of water or buried ice sheets. In the mid-2000s, both ESA and NASA sent spacecraft to Mars with radars capable of searching for these deposits.

ESA's MARSIS instrument and NASA's SHARAD are complementary ground-penetrating radar that gradually unveiled the truth.

In November 2016, SHARAD found a large deposit of subsurface ice in the Utopia Planitia region of Mars. This is a large expanse, some 3,300 kilometres across, and the volume of water contained in the ice was estimated to be enough to fill Lake Superior, the largest of the Great Lakes in North America. The top of the ice sheet is covered by between 1 to 10 metres of Martian dust, explaining why it has never shown up in optical images of the surface. "This deposit is probably more accessible than most water ice on Mars, because it is at a relatively low latitude and it lies in a flat, smooth area where landing a spacecraft would be easier than at some of the other areas with buried ice," says Jack Holt of the University of Texas, a SHARAD co-investigator. This means that it could one day help to sustain astronauts by being the Martian equivalent of a frozen water spring. It may also contain clues to whether life started on Mars or not.



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In July 2018, Mars Express's MARSIS instrument found evidence for a lake of water buried near the planet's south pole. The radar reflections show that the underground lake is more than a kilometre and a half below the surface, and approximately 20 kilometres wide.

"This is just one small study area; it is an exciting prospect to think there could be more of these underground pockets of water elsewhere, yet to be discovered," says Roberto Orosei, principal investigator of the MARSIS experiment.

The discovery is a bit similar to the subglacial lakes of Antarctica on Earth, and forms of microbial life are known to thrive in these environments. Reaching the Martian lake, however, would require serious technology. It's more than a kilometre and a half down and the Rosalind Franklin rover, which boasts the deepest drill ever to go to Mars, is only capable of penetrating two metres below the surface. Don't hold your breath on this one.

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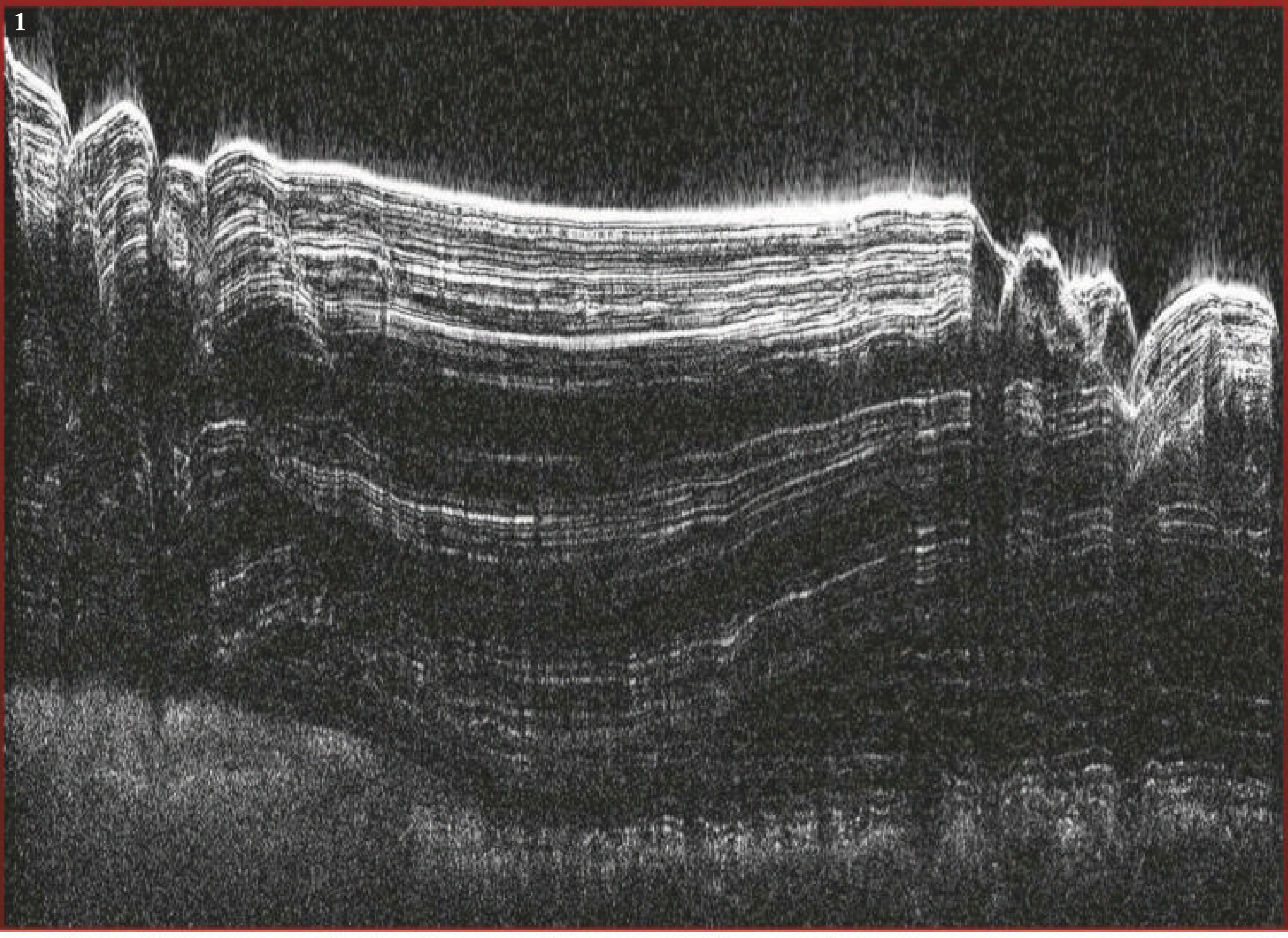

1 NASA's SHARAD used ground-penetrating radar to reveal layers of subsurface ice on Mars

2 Artist's impression of water beneath the Martian surface

NASA/JPL X2, ESA/AIRBUS

← ExoMars rover under construction in a clean room

PLANETARY PROTECTION

LIMITING THE RISK OF CONTAMINATION

In 1969, American novelist Michael Crichton wrote the bestselling thriller, *The Andromeda Strain*. It told the harrowing story of an outbreak of extraterrestrial microbes that had been brought back to Earth by a returning satellite. But what about contamination the other way – Earth microbes running amok on Mars?

The detection of life on Mars would be one of the greatest scientific discoveries of all time. So the last thing we should want to do is risk contaminating Mars by sending dirty spacecraft to the surface.

> "WE HAVE TO MAKE SURE THAT HUMANS DON'T CONTAMINATE THE ROVER WITH PARTICLES OF SKIN, HAIR, OR GREASES FROM THEIR SKIN"

The Committee On Space Research (COSPAR), an international organisation founded in 1958, sets strict standards to limit biological contamination between planetary bodies. As a result, the major space agencies go to extraordinary lengths to sterilise their spacecraft before sending them to areas on Mars that may be habitable.

Sterilising a spacecraft is no easy job. The first Mars landers were NASA's Viking 1 and 2. They needed to be well sterilised because they were looking for Martian microbes. Built in the 1970s, the surfaces of the spacecraft were first cleaned thoroughly to significantly reduce the 'bio-burden'. Then, they were placed in an oven and heated to 112°C for 30 hours. NASA estimated that the baking reduced the remaining bacteria by a factor of a million.

ESA's Rosalind Franklin rover must adhere to similar standards. "We have to make sure that during the actual build of the rover, which is almost entirely done by humans, that those humans don't contaminate the rover with particles of skin, hair, or greases from their skin. This means that the technicians have to do so in a specially built 'clean room', which is isolated from the normal working environment, and that they must wear full body protective gear," says Hutty.

Planetary protection will be a major concern when returning rocks from Mars for study in Earth's laboratories. The COSPAR guidelines call for the most stringent safeguard for such Category V missions, as they are known.

The European Space Agency's Mars rover undergoing tests

HAVE WE ALREADY FOUND MARTIAN LIFE?

SOME SCIENTISTS THINK THAT HINTS OF LIFE WERE DISCOVERED BACK IN THE 1970s

Considering all the talk surrounding life on Mars and all the many spacecraft and landers that have gone to the Red Planet since the 1970s, it may seem surprising that only the first two carried equipment to look for life. There were four biological experiments on the Viking spacecraft. Of these, only one returned positive results.

The Labeled Release experiment was simple. It took a sample of Martian soil and introduced some liquid nutrients. Those nutrients had been 'labelled' with a radioactive carbon isotope. If bacteria were present in the soil, they would metabolise the nutrient and expel the carbon isotope, which would be detected by the instrument. When the experiment was run on both landers, both returned positive results. The second part was to sterilise the soil and see if that made the signal go away. It did, no radioactive gas was detected that time.

"Right then and there we satisfied the pre-mission, agreed upon criteria for life. We could have said we've detected life, hung our hats up, grabbed a bottle of champagne and celebrated. That was not to be," said Gilbert Levin, who was the experiment's principal investigator. Instead, the researchers wondered why none of the other experiments had returned positive results, and declared that the Viking experiments were inconclusive but probably hadn't found life. Over the years, researchers have proposed various non-biological reactions that could reproduce some aspects of the experiment's results. Levin, however, has continued to champion the biological interpretation, claiming that no chemical has been able to totally mimic the results.

In 2012, Joseph Miller, a neurobiologist at the University of Southern California and a former NASA space shuttle project director, and mathematician Giorgio Bianciardi, from Italy's University of Siena, re-analysed the Viking data. Using maths, they showed the data was more consistent with biological activity than simple chemistry.

The only way out of the impasse is to look for life again, which is where ESA's ExoMars mission comes in. "The Rosalind Franklin rover's mission is to detect life, either past or present, on the Martian surface," says Hutty.

After all this time, maybe soon we will have the answer about whether there is life on Mars. **SF**

by **DR STUART CLARK**
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Stuart is an astronomy writer. His latest book, The Search For Earth's Twin (£12.99, Quercus) *is out now.*

ESA