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Space exploration

We're heading for Venus

Confirming potential signs of life on Venus may require a trip there, and several missions are already in the works, finds **Jonathan O'Callaghan**

AFTER decades of neglect, our closest planetary neighbour is suddenly the flavour of the month. On 14 September, scientists said they had found phosphine on Venus, a potential signature of life. Will this discovery usher in a new era of Venus exploration, like that of Mars before it?

The Red Planet was thrust into the limelight in 1996 when scientists said they had discovered evidence for fossilised life in a Martian meteorite called ALH84001 found in Antarctica. "If this discovery is confirmed, it will surely be one of the most stunning insights into our universe that science has ever uncovered," said President Bill Clinton at the time, in an address at the White House.

The announcement ushered in an era of Mars exploration that continues even now. In 1997, NASA sent its first rover to Mars, followed by a dozen other missions. The European Space Agency (ESA) has sent spacecraft too, as have India, Russia, the United Arab Emirates and China.

Today, scientists are less sure about ALH84001 as evidence for life. And while we now think that Mars was once habitable, current prospects for life there are slim. So Mars has started to lose its shine. The phosphine discovery has many wondering if we might see history repeat.

If phosphine is really present on Venus, and we can't work out a non-biological source in Venus's clouds, we could see a new rush to look for life, this time on our solar system's hottest planet.

"We invested billions of dollars in looking for life on Mars because of that discovery," says Sanjay Limaye at the University of Wisconsin-Madison. "So I wouldn't be surprised at all if we see a similar trajectory here from this initial finding."

NEWSCOM/ALAMY

In 2010, Japan sent the Akatsuki probe to study Venus's atmosphere

We know phosphine can be produced on Earth by anaerobic life, which requires no oxygen. Its supposed discovery 50 kilometres above the surface of Venus is in a region where conditions mimic

"This is about answering arguably the largest question about humanity: are we alone?"

those on Earth, and thus could be habitable – potentially to airborne microbes riding on droplets.

Until this announcement, phosphine hadn't been on many people's radar as a biomarker. "There are 16,367 molecules associated with life, by our latest count," says Clara Sousa-Silva at the Massachusetts Institute of Technology, a co-author on the phosphine discovery paper who has led much of the work on phosphine as a biomarker. "No one was looking for phosphine."

When Sousa-Silva was alerted to the presence of phosphine on Venus, however, she and her colleagues worked to find a possible source. After exhausting all options, they concluded it must either be produced on Venus by an unknown chemical process, or life.

Finding out will be a cautious process. First, scientists are working to confirm the presence of phosphine with independent observations from telescopes on Earth (see "Can we verify life on Venus?", page 12).

Several spacecraft are also due to fly past Venus in the coming months, including Europe and Japan's BepiColombo spacecraft en route to Mercury, which could look for phosphine in the Venusian atmosphere this month.

"There's definitely a limit of what we can do," says Jörn Helbert at the German Aerospace Centre, part of the BepiColombo team. "But it will not stop us from looking."

Into toxic skies

Beyond these near-term follow-ups, the next step would be sending dedicated missions to Venus to probe the phosphine in more detail. The three-month journey to get to Venus is about half the time needed to reach Mars.

"Venus is the easiest planet to get to," says Colin Wilson at the University of Oxford, who worked on ESA's Venus Express mission in 2006 and is part of a new mission proposal to Venus for ESA, EnVision. "Sending a spacecraft to orbit Venus is not that different from sending a spacecraft to orbit Mars. What is very different is landing on the surface."

EnVision, which would launch in 2032, is one of a number of proposed missions to Venus that were already on the table before the phosphine discovery. India also hopes to launch a mission this decade, while Russia has long talked of going back to Venus.

Japan's Akatsuki spacecraft is currently orbiting Venus, but its instruments lack the capabilities to look for phosphine.

EnVision, meanwhile, is a radar mission designed to study

the surface of Venus, not its atmosphere.

NASA is considering two new missions to Venus: DAVINCI+ and VERITAS. The former would include an atmospheric probe that could paint a broader picture of the Venusian atmosphere and gather some useful information.

2023

The year a Rocket Lab probe is pegged to launch towards Venus

"DAVINCI+ could provide the missing pieces critical to investigating where the phosphine is coming from," says NASA's Jim Garvin, the principal investigator on the mission proposal. He says the mission's chemical analysis of the planet could also tell us if Venus ever was, or still is, habitable.

Outside these national efforts, California-based aerospace company Rocket Lab says it plans to launch a small atmospheric probe to Venus as soon as 2023, to look for evidence of phosphine. The mission, which includes scientists involved in the phosphine discovery, would reach the Venusian atmosphere years before any other spacecraft.

"This is about answering arguably the largest question about humanity, and that is: are we alone?" says Peter Beck, CEO of Rocket Lab.

Another private venture, the Breakthrough Initiatives, is funding studies of potential life on Venus with a view to possibly developing a mission of its own. "We're hoping something comes out of this that's scientifically justifiable and affordable," says executive director Pete Worden.

Such ventures raise issues with regards to planetary protection. Mark McCaughrean at ESA says companies must ensure their missions don't contaminate Venus with Earth microbes. "There is no legal mechanism to prevent them from launching if they haven't followed planetary protection [guidelines]," he says.

To look for life itself on Venus, a dedicated mission that could sample the atmosphere would be needed, perhaps a machine that could float on a balloon, something done before by the Soviet Union.

"You'd have a pump that pulls in cloud particles onto filter paper, and you look at that filter paper using a microscope," says Wilson, part of a team that proposed such a mission in August 2020 called the Venus Flagship Mission. "That is the technique which has been proposed to look for biomolecules."

Eventually, we might want to get a sample back from the Venusian atmosphere, which poses further difficulties.

"You're going to have to have a full-scale launch vehicle dropped into Venus's atmosphere, and then launched back out of Venus orbit and brought home," says Dave Clements at Imperial College London. "That's quite a complicated mission. I don't think that's going to happen any time soon," he says.

In the nearer term, there are plausible routes to follow up the phosphine finding, and even if a biological source turns out to be unlikely – like with a certain Martian meteorite – the prospect of an era of Venus exploration spurred on by the discovery has many supporters, life or no life.

"If we still haven't sent anything to Venus in four or five years, or even considered sending anything, it will have been a waste," says Paul Byrne, a planetary scientist at North Carolina State University. ▮

SCIENCE HISTORY IMAGES/ALAMY

The BepiColombo spacecraft when it was under construction

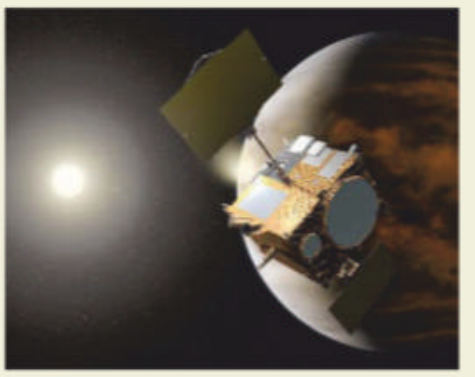
Missions to Venus

US space agency NASA might not have sent a dedicated mission to Venus since its Magellan spacecraft in 1989, but other nations have shown more interest.

In the 1970s and 1980s, the Soviet Union led much of the exploration of Venus. The country sent multiple probes and landers as part of its Venera programme, having had a mostly unsuccessful run of Mars missions in the 1960s.

In total, the Soviet Union performed 10 landings on Venus, returning stunning images from the ground, and is still the only state ever to operate a craft on the surface of the planet.

In 1985, the Soviet Union also deployed two balloons into the Venusian atmosphere, called Vega 1 and 2, the first and only missions of their kind to date. They floated at an altitude of about 54 kilometres and travelled on the Venusian wind for days. Unfortunately, neither had a camera to take images.



JAXA

NASA also sent two missions to our gas-shrouded neighbour in 1978: Pioneer Venus 1, which included an orbiter and a probe, and Pioneer Venus 2, a sister ship with four probes.

More recently, in 2006, the European Space Agency's Venus Express spacecraft became the first to orbit Venus in more than a decade, operating until 2014. It was followed by Japan's Akatsuki spacecraft (pictured launching, opposite) in 2015, which continues to operate today.