New Scientist

WEEKLY October 3 – 9, 2020

LAST OF THE MEGA FISH
Earth's vanishing river monsters

REASONS TO BE CHEERFUL
Ruby Wax on mindfulness and mental health

CHINA'S CLIMATE SURPRISE
Can it really go carbon neutral by 2060?

SPECIAL REPORT

LIFE BEYOND EARTH

The discovery on Venus, and the race to understand it

Have we been looking for life in all the wrong places?

Why we will (probably) never make contact with intelligent aliens

LOCKDOWN OR LET IT RIP?
Difficult decisions as European coronavirus cases rise once more

PLUS RAISED BY WOLVES / **THE PROBLEM WITH THE PALEO DIET** / **FIRST EXTRAGALACTIC EXOPLANET?** / A WHALE DIVING RECORD

Science and technology news **www.newscientist.com**

No3302 US$6.99 CAN$7.99

0 72440 30690 5

Astrochemistry

Can we verify life on Venus?

The hunt for alien life on Venus must start in labs on Earth to rule out other sources of the mysterious molecule we have seen, says **Leah Crane**

POSSIBLE signs of life have been glimpsed in Venus's atmosphere, but there is a significant amount of work required to confirm this unexpected finding before we can dive deeper into what it means.

On 14 September, a team announced that it had seen what appears to be phosphine gas in the Venusian atmosphere. On Earth, phosphine is only produced by living organisms or in industrial processes, and the researchers couldn't identify any way to make as much of the gas as they spotted on Venus through any known non-biological process. Phosphine is expected to be destroyed quickly in conditions like those in Venus's atmosphere, so something must be replenishing it.

> "The conditions in Venus's clouds are difficult to work with in the lab. They are either toxic or corrosive"

"Everyone is deeply excited, but at the same time we've got like a hundred things we've got to do," says Jason Dittmann at the Massachusetts Institute of Technology (MIT). "It's going to be really exciting over the next few years while we puzzle this one out."

First, we need to confirm that the team really did see phosphine. The group found it using a process called spectroscopy, which can identify certain compounds by the way they absorb light at particular wavelengths, leaving dark lines in the spectrum of any light that has passed through gas. Phosphine is expected to produce thousands of these absorption lines, but the team only caught one with the two telescopes they used.

Phosphine was the best match for that line, but it will be important to confirm it with observations of other absorption lines of phosphine at different wavelengths, says Clara Sousa-Silva at MIT, who is part of the discovery team. She and several of her colleagues had observations scheduled with other telescopes to confirm phosphine on Venus, but they have been delayed because of observatory closures caused by the covid-19 pandemic.

"Maybe it's phosphine, and if it's phosphine, maybe it's life," says Sousa-Silva. If her team confirms the finding, figuring out if that phosphine came from life will be a much more arduous endeavour.

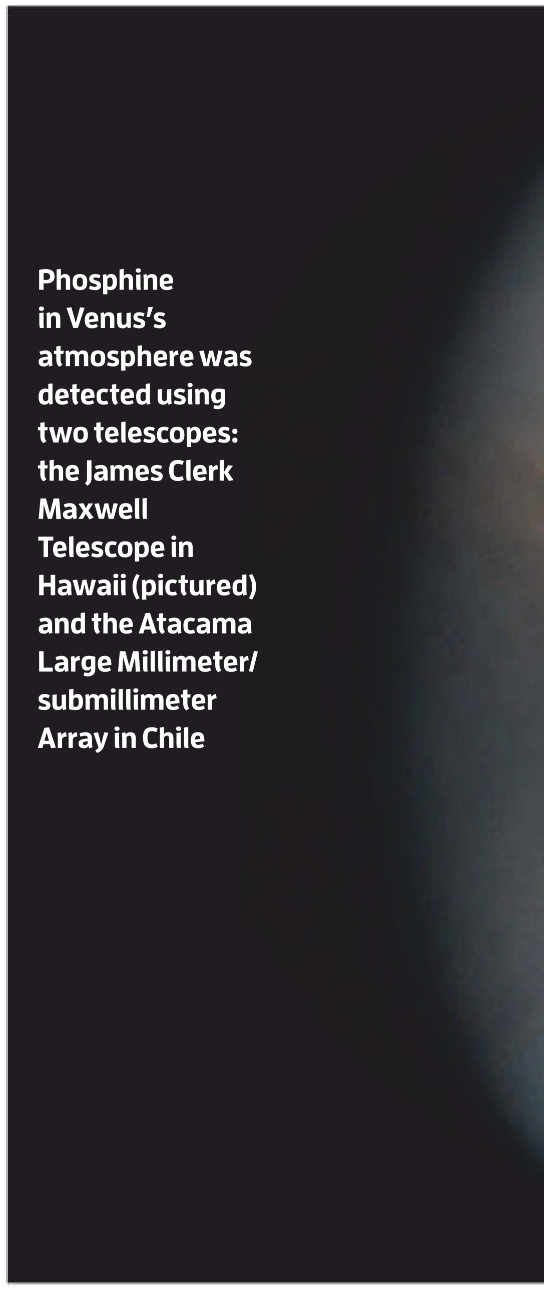
Thousands of experiments

One problem is our fundamental lack of understanding of both phosphine and Venus, which makes it hard to even say that finding phosphine there is totally unexpected. "Your ability to decide whether or not the presence of a molecule is weird is 100 per cent determined by how good your model is, and your model is only as good as the information you put into it," says Sarah Hörst at Johns Hopkins University in Maryland.

Right now, our models of both the Venusian atmosphere and the behaviour of phosphine are chock-full of educated guesses, says Sousa-Silva. To replace those guesses with reliable information, we need to study Venus's atmosphere in a lab setting. That is easier said than done.

"This work requires very specialised equipment, it takes a lot of time and a lot of the conditions in the Venus atmosphere are extremely difficult to work with in the lab, as are the materials, either because they are very toxic or very corrosive," says Hörst. Phosphine in particular is toxic for any organism that depends on oxygen, including humans.

To understand how phosphine might be produced, we need to



Phosphine in Venus's atmosphere was detected using two telescopes: the James Clerk Maxwell Telescope in Hawaii (pictured) and the Atacama Large Millimeter/submillimeter Array in Chile

not only overcome those issues, but also do an enormous number of experiments. We have to study how every type of molecule in the Venusian atmosphere interacts with every other molecule there, and how they interact with every wavelength of light. We must also study those interactions at every temperature and pressure in the atmosphere, which ranges from about 467°C and 9.3 megapascals at the planet's surface down to the cold vacuum of space at the atmosphere's top. And we also need to know how the atmosphere interacts with the planet's surface.

It could be that any one of these interactions produces phosphine. Or maybe it doesn't, but we have to check to be sure. "It's completely overwhelming," says Hörst.

Without all those experiments, we can't definitively rule out non-

What else could make phosphine?

To be sure that the phosphine gas discovered in Venus's atmosphere was a potential sign of life, the team that spotted it searched for other processes that could be behind it. These would need to maintain phosphine levels of around 20 parts per billion in the atmosphere despite its continuous destruction.

None of the reactions between chemicals that we know exist on Venus is likely to produce phosphine. It can be made in interactions between these chemicals and light, but the amount of phosphine produced is too low by a factor of at least 10,000.

Lightning striking compounds containing phosphorus could make trace amounts of phosphine – less than one part per trillion. And meteorites carrying phosphine, or the ingredients to make it, could account for only 10 times less than lightning.

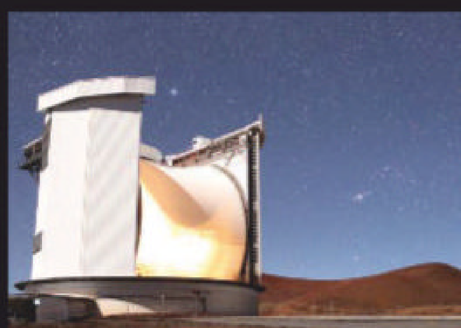
Volcanism could produce phosphine, but Venus would have to be at least 200 times more volcanic than Earth to blow enough phosphine into the air to account for the observations, and readings suggest that it isn't.

Even the most exotic processes could produce only tiny amounts of phosphine, so either Venus has unexpected chemical processes, or the phosphine is produced by something alive.

467°C
Temperature on the surface of Venus

9.3
Pressure in megapascals on the surface

20
Parts per billion of phosphine detected in Venus's atmosphere



L-R JAXA/ISAS/AKATSUKI PROJECT TEAM; WILL MONTGOMERIE/EAO/JCMT

biological sources of phosphine on Venus. The original team used what we currently know to rule out non-biological phosphine sources (see "What else could make phosphine?", left), but the chances are still fairly high that there are chemical interactions on Venus that we simply don't yet understand, says Sousa-Silva.

If we don't get a handle on how those interactions ought to work,

> **"Microbes could be chomping volcanic ash and spitting out phosphine as a waste product"**

it will only make it more difficult to design a spacecraft to observe them on Venus. "I am not immune to being excited about a shiny machine going to the Venus clouds and having a space robot taking samples, but even if we get a probe there and we sample it, the analysis of that sample will only be as good as our fundamental knowledge of how these gases behave," says Sousa-Silva. "It's not as shiny, but it is important."

Ideally, lab experiments and direct observations of Venus should go hand in hand, providing accurate models with which to compare atmospheric measurements. To sort out whether the phosphine came from life, we need the right combination of experiments, theoretical modelling and observations.

"Maybe this is just weird chemistry, fine – that's still a compelling reason to go and sample this stuff, get instruments in orbit to look at how phosphine changes over time, get probes into the atmosphere to sample it and figure out where it came from," says Paul Byrne at North Carolina State University.

What does life look like?

There are several spacecraft in development to visit Venus in the coming decades (see "We're heading for Venus", page 14), none of which has hunting for life as a prime directive. "The search for life on Venus is still sort of a taboo topic, it's still considered fringe. So typically, planned missions would not state that their main goal is to search for signs of life or life itself," says Sara Seager at MIT. "Hopefully with this news, those missions can tailor their instruments to look for signs of life."

Even if the missions can change their science goals to hunt for life, we don't know what Venusian life would look like. There are still heated arguments about what constitutes a living organism on Earth, let alone on a planet with different chemistry, where life could be thoroughly unfamiliar.

"It's actually a lot more challenging to find life than abiotic processes, because what does life mean?" says Seager. "You can imagine taking a microscope to Venus, but there are a lot of other cell-like particles there." Non-biological particles could masquerade as living microbes, or vice versa.

If the planned missions to Venus can't look directly for living organisms, we will have to rely instead on other clues that could point to life indirectly. For example, the BepiColombo spacecraft is about to swing past Venus on its way to Mercury – it will look for phosphine, but also for compounds that could indicate if Venus has active volcanoes.

"Current volcanism would make it more likely that it is life because that's a way to get the trace metals that you need for life into the atmosphere," says BepiColombo team member David Rothery at the Open University, UK. "The microbes could be chomping this volcanic ash and spitting out phosphine as a waste product."

We don't know enough about volcanism on Venus to discount it as a potential mechanism to produce phosphine directly, according to a paper published after the discovery was announced (arxiv.org/abs/2009.11904). The authors suggest that if Venus is volcanically active today, it could theoretically produce enough phosphine to account for the measurements.

The bottom line is that understanding the possibility of life on Venus requires first understanding Venus itself – a monumental task that we are only just beginning to tackle. ■