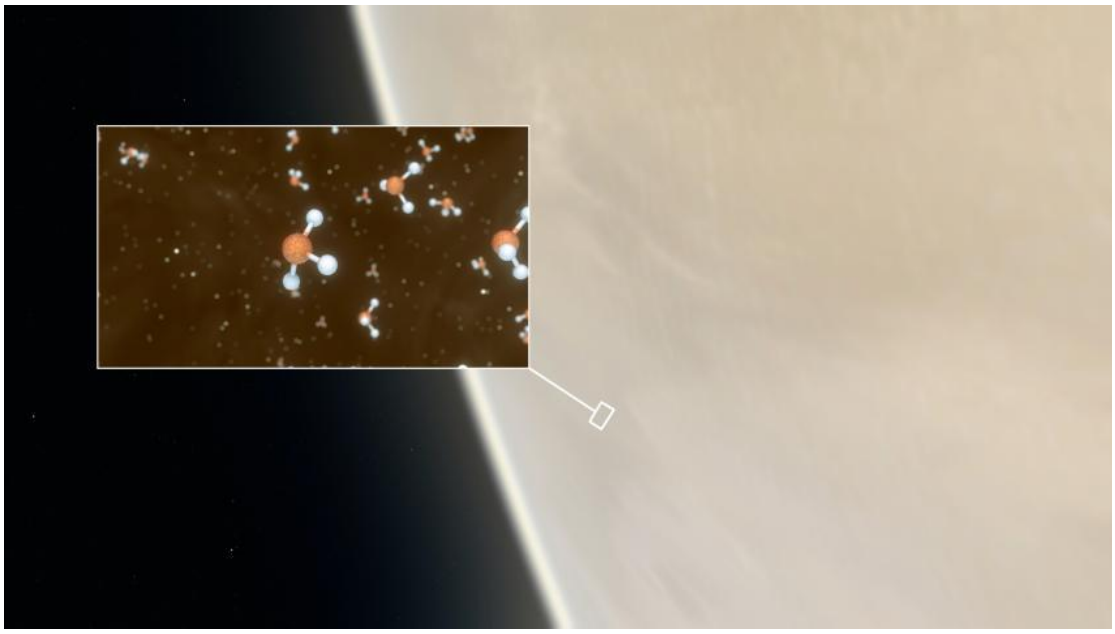
Venus: A quest for life

Guo Zhuan, Department of Earth and Planetary Science, the Univerisy of Tokyo

What do you think about when you gaze at the stars in the night sky? Do you wonder about the origin of the universe, the destiny of humanity, or the possibility of alien life on distant planets? On September 14, 2020, the Royal Astronomical Society announced that scientists had detected a gas called phosphine (PH_3) in the highly acidic atmosphere of Venus, at an unusually high concentration. This toxic, flammable, and foul-smelling gas is often involved in life processes and produced by microorganisms on Earth, which is considered a biosignature in astrobiology. The discovery sparked the curiosity of researchers: could this be a clue to extraterrestrial life, or just a result of unknown photochemical or geochemical processes?



Artist's impression of Venus, showing a representation of the phosphine molecules detected in the high cloud decks.
Credit: ESO / M. Kornmesser / L. Calçada & NASA / JPL / Caltech

Venus, often called Earth’s sister planet, is the second planet from the Sun and has a similar size and mass to Earth. It is one of the brightest objects in the night sky and

has significantly influenced human culture since ancient times. For instance, Venus was named after the Roman goddess of love and beauty, and her astrological symbol is still used to represent females in biology. Naturally, people could not stop wondering: is there any life on Venus? Unfortunately, according to the exploration from the last century, Venus is far from being a paradise. Its surface conditions are extremely hostile to life, with a pressure 92 times that of Earth's and a temperature as high as 900°C (at least 462°C on average), hot enough to melt lead. Although Mercury is the closest one to the sun, Venus is the hottest planet in the solar system.

However, things seem to have taken a turn due to the recent discovery of phosphine on Venus. The team behind this discovery was led by Jane Greaves, a professor at Cardiff University in the UK. She observed planets in the solar system, such as Pluto, Saturn, and their moons, searching for signs of life. She and her team used the James Clerk Maxwell Telescope (JMCT) in Hawaii to observe Venus's atmosphere. They did not expect to find phosphine molecules, since phosphine would be rapidly destroyed in their highly oxidized crusts and atmospheres, while Venus's atmosphere is full of carbon dioxide and is highly acidic, leading to phosphine production unlikely. However, they detected phosphorus absorption lines. (Absorption lines represents identical wave bands where the radiation was absorbed by certain materials. It has been widely used to identify molecules.) They initially thought it was an error signal, but further analysis convinced them that phosphine was the most likely explanation.

In 2019, they made another observation with Atacama Large Millimeter/ Submillimeter Array (ALMA), a more powerful telescope located in Chile. They detected phosphorus absorption lines again and estimated the abundance of phosphine at 20 ppb (20 particles per billion) in Venusian clouds, around 53 kilometers from the surface. Although 20 ppb sounds insignificant, it is thousands of times the concentration in Earth's atmosphere and scientists believe it is unreasonably high. The acidic conditions in Venusian upper atmosphere would destroy phosphine molecules quickly, with an average lifetime of only 16 minutes. Therefore, there must be a large

and stable source of phosphine on Venus.

Greaves' team investigated the possible sources of phosphine on Venus. They considered various ways that phosphine could be produced, including micrometeorites, lightning, chemical reactions from the surface and the clouds of Venus. Nevertheless, none of these explanations seemed plausible. Phosphorus-containing minerals are one possible source, yet the phosphine produced in this way is unlikely to drift to such high altitudes from the surface. Lightning and the solar wind produce too little gas, which is inconsistent with observations. According to the emission of phosphines from Volcanoes on Earth, and Venus would need to be 200 times more volcanically active than Earth to reach the same amount as detection. Another possibility is that phosphine comes from organic sources. Some microbes on Earth that thrive in low-oxygen environments produce phosphine. Moreover, the cloud layer of Venus has the temperature of about 30°C, similar to Earth's, and a small amount of water, which are conducive to the formation and presence of life. Thus, some researchers proposed that some unknown life forms might exist there.

However, could we conclude that there is life on Venus? Unfortunately, the answer is no. Although phosphine molecules may be produced by life forms on Venus, the detection of phosphine cannot be taken as strong evidence for the presence of microbial life, but only as an indication that unknown geological or chemical processes may be occurring on Venus. Other scientists have questioned the accuracy of the phosphorus absorption lines, which is faint and could be a result of ordinary sulfur dioxide or contaminated by artificial signals at the same frequency. The debate is ongoing and therefore more observation and analysis are needed.

The quest for extraterrestrial life is a longstanding question for mankind. Currently, we are standing in front of a possibility that may lead us to the discovery of alien life on other planets. Researchers are planning to re-visit Venus with probes, which would measure the planetary atmosphere and bring back samples to Earth for further

analysis. As new techniques developing and exploration missions launching, science community always provides great opportunities for those who are interested in adventure and aspire to planetary exploration. In the exploration of the universe, we humans will become more aware of our origins and destiny, and you can be the Columbus in 21 century and open up new world for human.

References:

Greaves, J.S., Richards, A.M.S., Bains, W. et al. Phosphine gas in the cloud decks of Venus. Nature Astronomy (2020). https://doi.org/10.1038/s41550-020-1174-4

Royal Astronomical Society. Venus phosphine detection factsheet (2020). https://ras.ac.uk/news-and-press/news/venus-phosphine-detection-factsheet

Nadia, D. Possible sign of life on Venus stirs up heated debate. National Geographic (2020). https://www.nationalgeographic.com/science/2020/09/possible-sign-of-life-found-on-venus-phosphine-gas/

Sid P. ‘Curious and unexplained.' Gas spotted in Venus's atmosphere is also spewed by microbes on Earth. Science (2020). https://www.sciencemag.org/news/2020/09/curious-and-unexplained-gas-spotted-venus-s-atmosphere-also-spewed-microbes-earth

Adam, M. Venus Might Host Life, New Discovery Suggests. Scientific American (2020). https://www.scientificamerican.com/article/venus-might-host-life-new-discovery-suggests/

Acknowledgement:
This essay is completed with assistance from DeepL and Bing. DeepL was used for translation. Bing was used to search the picture, background knowledge, and articles cited in this essay. I did not receive any advice from colleagues or acquaintances and did not use the generative AI, such as ChatGPT.
I’m grateful to Mark Vagins and Uchida Yoshihito for their valuable advice on this essay.