The Controversy about Possible Life in the Venusian Cloud Deck: What are the next Steps to Gain further Insights

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Arguments in favor of Life

- Habitable temperatures and pressures in continuous, stable cloud environment
- Super-rotation of atmosphere and sufficient available energy, suitable for photosynthesis
- If present, life in clouds likely evolved from past life on the Venusian surface
- Availability of critical nutrients C,N,S & P

Some speculative solutions to habitability challenges in the Venusian atmosphere:

(1) Aerosols might be cells coated by elemental sulfur (S_8), absorbing UV radiation and allowing photosynthesis reactions to occur, which in turn causes disequilibrium conditions and permitting the possible presence of microbial life [1]

(2) Elemental sulfur is not wetted by sulfuric acid. Putative cells might only adhere to sulfuric acid droplets rather than being fully enveloped, thus lowering the water activity and acidity stress they would otherwise be exposed to [2]

(3) In addition to sulfur, putative cells would also need to be coated by hydrophilic filaments to take up critical liquids [3]

(4) Microbial life may have the ability to go through a spore state to lower the expected cell losses in the haze layer [3]

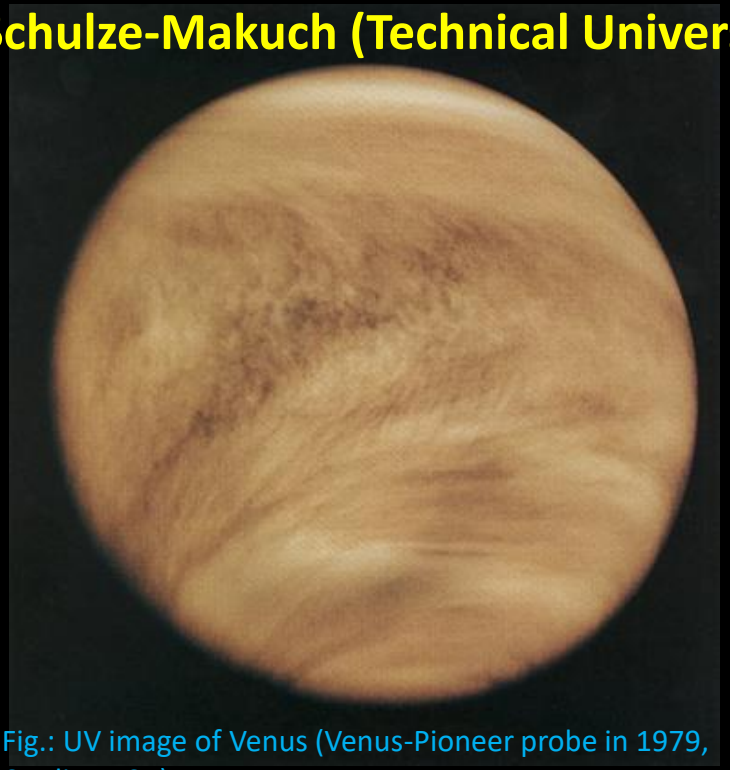

Fig.: UV image of Venus (Venus-Pioneer probe in 1979, Credit NASA)

The claimed presence of phosphine [4] brought up again the discussion of possible life in the Venusian clouds, but is phosphine really present? - are organics present?

References

1. Schulze-Makuch et al. (2004) *Astrobiology* 4: 11-18.
2. Petrova, E.V. (2018) *Icarus* 306: 163-170.
3. Seager et al. (2020) *Astrobiology* 20, 10.
4. Greaves, J.S. et al. (2020) *Nature Astronomy* 5, 655-664.
5. Schulze-Makuch (2021) *Life* 11, #255, doi.org/10.3390/life11030255

Arguments against Life

- Extremely low overall water activity, which appears to require unknown biochemical pathways to overcome
- Sulfuric acid concentrations are in a range that life on Earth could not cope with
- Likely lack of trace metals and hydrogen

Next steps as detailed in [5]:

(1) Try to detect phosphine in the IR range and also diphosphine as an intermediate product in the photolysis reaction of phosphine to phosphorous and hydrogen

(2) Investigate microbial adaptation mechanisms to hyperacidity, low water activity, and the lack of trace metals

(3) Test selected acidophilic microbes how far they can adapt from one generation to the next to higher and higher sulfuric acid concentrations

(4) Launch missions to Venus (Davinci+, Veritas, EnVision) to obtain new results. Especially desirable would be a mission to crack open the mode 3 particles to reveal their interior composition (the Venus Pioneer was supposed to do that but failed because the pyrolyzer malfunctioned)