PHOSPHORUS IN THE CLOUDS OF VENUS: POTENTIAL FOR BIOAVAILABILITY. Tetyana Milojevic[1], Allan H. Treiman[2], and Sanjay Limaye[3], [1]Space Biochemistry Group, Department of Biophysical Chemistry, University of Vienna, Vienna, Austria, [2]Lunar and Planetary Institute, USRA, Houston, Texas, USA; [3]Space Science and Engineering Center, University of Wisconsin, Madison, Wisconsin, USA.

Aerosol phase elements such as phosphorus (P), sulfur (S), and metals including iron (Fe) are essential nutrients that could help sustain potential biodiversity in the cloud deck of Venus. While the presence of S and Fe in the venusian cloud deck has been broadly discussed (Zasova et al., 1981; Krasnopolsky, 2012, 2013, 2016, 2017; Markiewicz et al., 2014), less attention has been given to the presence of P in the aerosols and its involvement in the multiphase chemistry of venusian clouds and potential sources of P deposition in the venusian atmosphere. A detailed characterization of phosphorus atmospheric chemistry in the cloud deck of Venus is crucial for understanding its solubility and bioavailability for potential venusian cloud microbiota (Schulze-Makuch et al., 2004; Grinspoon and Bullock, 2007; Limaye et al., 2018). We summarize our current understanding of the presence of P in the clouds of Venus and its role in a hypothetical atmospheric (bio)chemical cycle. The results of the VeGa lander measurements are put into perspective with regard to nutrient limitation for a potential biosphere in venusian clouds. Our work combines the results of the VeGa measurements and focuses on P as an inorganic nutrient component and its potential sources and chemical behavior as part of multiple transformations of atmospheric chemistry. The VeGa data indicate that a plentiful phosphorus layer exists within a layer that reaches into the lower venusian clouds and exceeds minimum P abundances for terrestrial microbial life (Figure 1) (Milojevic et al., 2021). Extreme acidification of airborne phases in the atmosphere of Venus may facilitate P solubilization and its bioavailability for a potential ecosystem in venusian clouds. Further sampling and P abundance measurements in the atmosphere of Venus would improve our knowledge of P speciation and facilitate determination of a bioavailable fraction of P detected in venusian clouds. The previous results deserve further experimental and modeling analyses to diminish uncertainties and understand the rates of atmospheric deposition of P and its role in a potential venusian cloud ecosystem.

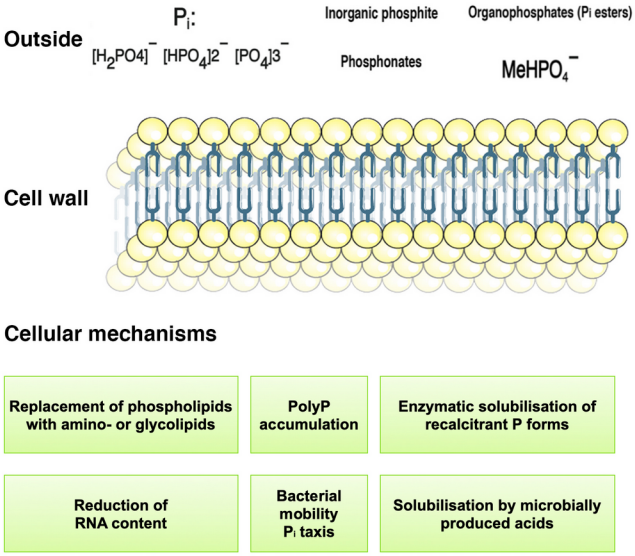

Figure 1. Microbial phosphorus acquisition and strategies for life in phosphorus-poor terrestrial environments.

References:

Grinspoon DH and Bullock MA (2007) Astrobiology and Venus exploration. In Exploring Venus as a Terrestrial Planet, Vol. 176, edited by LW Esposito, ER Stafan, and TE Cravens. American Geophysical Union, Washington, DC, pp 191–206.

Krasnopolsky VA (2012) A photochemical model for the Venus atmosphere at 47–112 km. Icarus 218:230–246.

Krasnopolsky VA (2013) S3 and S4 abundances and improved chemical kinetic model for the lower atmosphere of Venus. Icarus 225, doi:10.1016/j.icarus.2013.04.026.

Krasnopolsky VA (2016) Sulfur aerosol the clouds of Venus. Icarus 274:33–36.

Krasnopolsky VA (2017) On the iron chloride aerosol in the clouds of Venus. Icarus 286, doi:134.10.1016/j.icarus.2016 .10.003.

Limaye SS, Rakesh M, Smith DJ, et al. (2018) Venus' spectral signatures and the potential for life in the clouds. Astro- biology 10:1181–1198.

Markiewicz WJ, Petrova E, Shalygina O, et al. (2014) Glory on Venus cloud tops and the unknown UV absorber. Icarus 234: 200–203.

Milojevic T, Treiman AH, Limaye S. (2021) Phosphorus in the Clouds of Venus: Potential for Bioavailability. Astrobiology. doi: 10.1089/ast.2020.2267.

Schulze-Makuch D, Grinspoon DH, Abbas O, et al. (2004) A sulfur-based survival strategy for putative phototrophic life in the venusian atmosphere. Astrobiology 4:11–18.

Zasova LV, Krasnopolsky VA, Moroz VI, et al. (1981) Vertical distribution of SO2 in upper cloud layer of Venus and origin of UV absorption. Planet Aeronomy Astronomy. Available online at http://adsabs.harvard.edu/abs/1981paa ..conf...13Z