

VENUS, AN ASTROBIOLOGY TARGET. S.S. Limaye¹, R. Mogul², K.H. Baines³, M.A. Bullock⁴, C. Cockell⁵, J.A. Cutts³, D.M. Gentry⁶, D.H. Grinspoon⁷, J.W. Head⁸, K.-L. Jessup⁹, V. Kompanichenko¹⁰, Y.J. Lee¹¹, R. Mathies¹², T. Milojevic¹³, R.A. Pertzborn¹, L. Rothschild⁶, S. Sasaki¹⁴, D. Schulze-Makuch¹⁵, D.J. Smith⁶ and M. J. Way¹⁶

¹University of Wisconsin, ²Cal Poly Pomona, ³JPL/CalTech, ⁴Science and Technology Corp., ⁵University of Edinburgh, ⁶NASA/ARC, ⁷Planetary Science Institute, ⁸Brown University, ⁹SwRI-Boulder, ¹⁰ICARP/RAS Birobidzhan, Russia, ¹¹Technical University of Berlin, ¹²UC-Berkeley, ¹³University of Vienna, ¹⁴Tokyo University of Technology, ¹⁵Technische Universität Berlin, Berlin, Germany, ¹⁶NASA/GISS

Introduction: The interest in the possibility of life on Venus is driven not just by curiosity about life originating in another Earth-like environment, but because of the possibility that life may be playing a critical role in the planet's present, and possibly its past, atmospheric state. The brilliance of Venus in the night sky (as viewed from Earth) is due to its highly reflective cloud cover, about 28 km thick at the equator. Its spectral albedo is about 90% at wavelengths > 500 nm, but it drops gradually to about 40% around 370 nm before rising slightly at shorter wavelengths. This albedo drop is due to the presence of several absorbers in the atmosphere and the cloud cover. A very large fraction of the energy absorbed by Venus is at ultraviolet wavelengths with sulfur dioxide above the clouds contributing to the absorption below 330 nm; however, the identities of the other absorbers remain unknown. The inability to identify the absorbers that are responsible for determining the radiative energy balance of Venus over the last century is a major impediment to understanding how the planet "works", a major component of NASA's efforts in planetary exploration. Limaye et al. (1) presented a hypothesis suggesting that cloud-based microbial life could be contributors to the spectral signatures of Venus' clouds, building upon previous suggestions of the possibility of life in the clouds of Venus (2-5).

Themes: We suggest a set of four interconnected themes for the exploration of Venus as an astrobiology target – (i) investigations focused on the likelihood that liquid water existed on the surface in the past leading to the potential for the origin and evolution of life, (ii) investigations into the potential for habitable zones within Venus' clouds and Venus-like atmospheres, (iii) theoretical investigations into how active aerobiology may impact the radiative energy balance of Venus' clouds and Venus-like atmospheres, and (iv) application of these investigative themes towards better understanding the atmospheric dynamics and habitability of exoplanets. These themes can serve as a basis for proposed Venus Astrobiology Objectives and suggestions for measurements for future missions, as per the goals and objectives developed by the Venus Exploration Analysis Group (VEXAG), which is

sponsored by NASA to plan for the future exploration of Venus. Similarly, they can inform laboratory work that can begin now in support of potential mission approaches and instruments and their required technical development. The scientific investigation of Venus has also been discussed in two recent reports - Search for Life across Space and Time (National Academies of Sciences and Medicine 2017) and "An Astrobiology Strategy for the Search for Life in the Universe" (National Academies of Sciences and Medicine 2019).

Related research: Additional information about the astrobiology interest in future exploration of Venus can be found in the Venus Collection to be published in Astrobiology in the coming months. This collection will include papers prepared following the first workshop, "Habitability of the Venus Cloud Layer" held in Moscow in October 2019 with support from the Russian Academy of Science and NASA.

References

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