THE CONTROVERSY ABOUT POSSIBLE LIFE IN THE VENUSIAN CLOUD DECK: WHAT ARE THE NEXT STEPS TO GAIN FURTHER INSIGHTS? D. Schulze-Makuch[1,2], [1]Technical University Berlin, Astrobiology Group, ZAA, Hardenbergstr. 36, 10623 Berlin, Germany, schulze-makuch@tu-berlin.de, [2]School of the Environment, Washington State University, Pullman, WA 99164, USA

Introduction: The claimed detection of phosphine in the Venusian atmosphere [1] reignited the discussion about possible life at Venus. While many in the scientific community are convinced that the environmental conditions are too harsh for life to exist [e.g, 2,3], others point to the assertion that early Venus was habitable and that microbial life on Venus could have adapted to the currently extreme conditions by natural selection [e.g., 4,5]. Arguments in favor for possible life in the Venusian clouds are that (1) habitable temperatures and pressures exist in a continuous, stable cloud environment, (2) there is sufficiently available energy that makes photosynthesis in the clouds possible as a metabolic strategy, (3) life could have evolved from a early surface habitat (ocean) to a cloud habitat, and (4) critical elements such as C,N,S and P are thought to be available in the atmosphere [6]. Arguments against life include (1) the extremely low water activity which appears to require unknown biochemical pathways to overcome, (2) sulfuric acid concentrations that are extrapolated to be in a range that life on Earth could not cope with, and (3) the likely lack of trace metals and hydrogen [6]. The claimed detection of phosphine, a biomarker in an oxidizing environment – such as the Venusian [7] -, would be an argument in favor of life, if it can be confirmed.

Next Steps and Questions to be Answered. The first question to be answered is whether the phosphine detection is real or whether perhaps SO_2 was misidentified as phosphine [8]. To test, we should try to detect phosphine in the infrared range and confirming it by LNMS mass spectra [9]. We should also search for diphosphine, because it would be an expected intermediate in the photolysis reaction of phosphine to phosphorus and hydrogen.

Another step is to investigate what kind of mechanisms could be envisioned as an adaptation to hyperacidity and extreme lack of liquid water? For example, in some hyperarid environments on Earth, life can obtain all of its needed water through deliquescence [10]. Could there be similar "tricks" to meet the challenge of living in an hyperarid environment like the Venusian atmosphere? Though there is no organism on Earth that could live in the Venusian clouds, that may not mean that possible adaptation mechanisms cannot exist. Hyperacidic low-water activity environments are rare on Earth, and there may have not been enough selection pressure on Earth to develop adaptations to these conditions.

Complimentary to the proposed theoretical work, laboratory experiments should be conducted to test selected acidophilic microorganisms on their limit to sulfuric acid concentrations. Can this limit be enhanced from generation to generation as was shown for the gradual adaptation of microbes to perchlorates [11]? Trace metals are critical for life on our planet as well. How could putative life at Venus compensate for the lack of important trace metals? Laboratory experiments to find out should ideally be conducted in very acidic environments. This is not only important for possible life on Venus but would also be useful information to have when exploring other extraterrestrial locations.

Upcoming Missions: Three missions to Venus have been approved, two by NASA (DAVINCI+ and VERITAS) and one by ESA (EnVision), and these missions are well-suited to find answers to some critical questions, especially how Venus became the planet it is today. Did Venus have plate tectonics during its natural history and are there still active volcanoes on Venus, which may release water vapor and effect its habitability? The CUVIS instrument on DAVINCI+ may be especially important by revealing the nature of the unknown UV absorber, which absorbs up to 50% of solar energy. These missions will improve our knowledge of the Venusian environment tremendously, and without understanding the environment we cannot possibly hope to understand any life thriving in it. Even if there is no current nor past life on Venus, it is still critical to understand the extreme greenhouse effect that encompassed Venus. Earth may have a very similar fate in the future.

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