

TOWARDS AN EXPLANATION FOR VENUSIAN CLOUD ANOMALIES AND IMPLICATIONS FOR THE HABITABILITY OF THE CLOUDS. J. J. Petkowski¹, W. Bains^{1,2}, P. B. Rimmer³, S. Seager¹,

¹Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA, ²School of Physics & Astronomy, Cardiff University, 4 The Parade, Cardiff CF24 3AA, UK,

³Department of Earth Sciences, University of Cambridge, Downing St, Cambridge CB2 3EQ, UK.

Introduction: Scientists have been speculating on Venus as a habitable world for over half a century (e.g. [1]), based on the Earth-like temperature and pressure in Venus' clouds at 48-60 km above the surface. The hypothesis that Venusian clouds may be inhabited by an aerial biosphere got recently bolstered by a tentative detection of a biosignature gas phosphine in the atmosphere of Venus [2,3]. Phosphine however is not the only anomaly that suggests very unusual chemical processes in the clouds, and maybe even life. The presence of such chemical anomalies came to the forefront thanks to the recent efforts to re-analyze and re-interpret the legacy data collected by both the Pioneer Venus and Venera probes [4].

New Interpretation of the Venusian Cloud Anomalies: Many chemical anomalies observed by both Venera and the Pioneer Venus have been dismissed as artefactual on the grounds that models do not explain them; we argue for a new interpretation, in which it is the model, not the data that is incorrect. We present a new transformative hypothesis for the chemistry of the clouds of Venus, that builds on previous work by Rimmer et al [5]. Our model predicts that the clouds are not entirely made of sulfuric acid, but of ammonium salt slurries, which may be the result of biological production of ammonia in cloud droplets. As a result, the clouds are no more acidic than some terrestrial environments that harbor life. Our model explains many decades-long anomalies (Figure 1) including the observed SO₂ and H₂O abundance profiles and the presence of O₂ in the cloud layers. Furthermore, the model's predictions for the abundance of gases in Venus' atmosphere matches observation better than any previous model and are readily testable [6].

Critical Future Measurements: An *in situ* Venus probe can support or refute our proposed view of Venus as an inhabited planet with the following measurements.

Gases:

- Establish the co-existence of NH₃ and O₂ in the cloud layers.
- Determine the specific altitude-dependent abundance profiles of H₂O, SO₂, and H₂S.

Cloud particles:

- Confirm the non-spherical, semi-solid nature of Mode 3 cloud particles and identify them as ammonia salts.
- Measure the pH of cloud particles, especially Mode 3 cloud particles.

Search for life:

- Analyze a large number of individual cloud particles, especially Mode 3, for morphological and chemical signs of life.

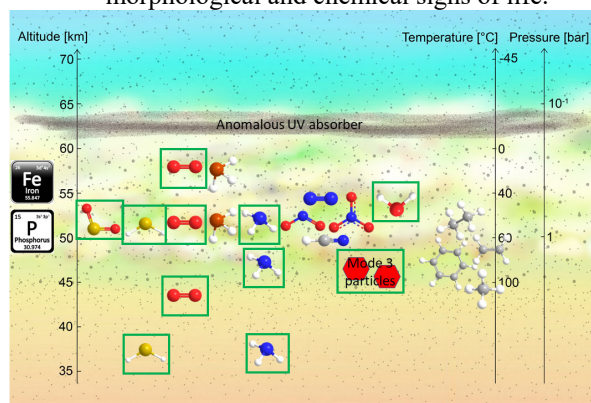


Figure 1. Venus atmosphere anomalies and their possible association with life. Our new model [6], based on the work of Rimmer et al [5], proposes an explanation for the anomalous measurements shown in green squares.

Conclusions: We conclude with a call for more data from the legacy dataset. Regardless of whether our particular model is right, it is clear that there are a lot of unknowns about Venus. New missions to Venus will add data to resolve some of the lingering questions. Even so, we believe that if legacy data were made available, particularly data from the Russian Venera and Vega missions, this data could support or refute current models and predictions, and would provide needed context for future mission results.

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References: [1] Seager S. et al. (2021) *Astrobiology* in press. [2] Greaves J. S. et al. (2021) *Nature Astronomy*, 5, 655-664. [3] Bains W. et al. (2021) *Astrobiology*, in press. [4] Mogul R. (2021) *GRL*, 48, e2020GL091327. [5] Rimmer P. B. (2021) *Planet. Sci. J.*, 2, 133. [6] Bains W. et al. (2021) *PNAS*, in review.