AN EXPERIMENT TO INVESTIGATE VENUS’S DEEP ATMOSPHERE. S. Lebonnois1, G. Schubert2, J. Bellan3, T. Kremic4, L. Nakley4, K. Phillips5, T. Navarro2, 1 LMD/IPSL, Sorbonne Université, Campus P&M Curie, CNRS, Paris, France (sebastien.lebonnois@lmd.jussieu.fr), 2 Department of Earth, Planet. and Space Sci., UCLA, Los Angeles, CA, USA, 3 Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, 4 NASA Glenn Research Center, Cleveland, OH, USA, 5 HX5 Sierra, LLC, NASA GRC, Cleveland, OH, USA.

Introduction: The characteristics of the Venus atmosphere closest to the ground are still unknown to a large degree. The only reliable temperature profile measured below 12 km altitude was obtained in 1985 by the VeGa-2 lander [1]. This profile, obtained during the ~1h descent, is highly unstable in the lowest 7 km, meaning that the near-constant vertical gradient is steeper than the adiabat, a characteristic that may be explained by a variation of the abundance of nitrogen from 3.5% at 7 km altitude to 0 at the surface, as proposed by Lebonnois & Schubert (2017) [2]. The physics of the composition gradient is difficult to understand in the absence of more information. However, considering the observations in a recent experiment [3] (designed by H13 below), it was conjectured that this gradient could result from gravity effects inducing a density-driven separation of nitrogen and carbon dioxide.

Experiment with GEER: To investigate the behavior of the CO2–N2 mixture under conditions ranging from the H13 experiment to the near-surface atmosphere of Venus, we have designed an experiment that was conducted at the “Glenn Extreme Environments Rig” (GEER) [4], at NASA Glenn Research Center in Cleveland in August 2018. The CO2–N2 gas mixture experienced experimental conditions of 100 bar at various temperatures in a 66 cm vertical steel pressure vessel with an internal diameter of 8.7 cm. The composition of the gas mixture was measured using gas chromatography at the top, middle and bottom of the vessel, to investigate the vertical composition gradient. To increase the accuracy of the measured abundance of nitrogen, mass spectrometry was also used in some cases. The first step in our experiment was to use the H13 experimental conditions, with a mixture of 50% CO2 / 50% N2 at 296K and 100 bar, to inquire whether the strong vertical gradient observed (i.e. 70% N2 at the top, 10% N2 at the bottom) in the H13 18-cm tall experimental vessel [3] was reproducible. Then, fixing the temperature at 310K and the pressure at 100 bar, we varied the abundance of nitrogen from 50% to 3%, to reach a proportion resembling the Venus atmosphere. In a second phase, maintaining the pressure at 100 bar and the nitrogen abundance at 3%, the temperature was step-wise increased up to 735K, so as to reach Venus’s near-surface conditions. At every step, the vertical gradient of nitrogen in the 66-cm high vessel was measured.

Preliminary results: For each test condition, the CO2–N2 mixture was delivered to the vessel by two different methods. First, CO2 and N2 were premixed in a separate tank and then transferred to the vessel as a single, well-mixed fluid. Gas chromatography was used to verify the mixture before transferring to the vessel. Secondly, after evacuating the test vessel, a layered mixture was inserted by first injecting CO2, then N2 – the same type of technique performed in the H13 experiment. A full analysis of our experiment results has not been completed. An initial inspection of the data appears to indicate that:

(1) For the well-mixed batch of gas, the composition was measured at all three ports during roughly 15 hours in each configuration. The results appeared to be the same: the composition is identical at all three ports, and stable. No density-driven separation is observed.

(2) To understand the H13 experiment, the same protocol was used: introducing CO2 first, then N2. To reproduce a similar mixture of gas, the masses used for each gas were roughly the same. In these cases, the first samples indicated nearly 100% CO2 at the bottom port and nearly 100% N2 at the top port. The composition evolved very slowly over time at each port, with time scales of the order of days. The composition was measured over at least 24 hours, over 3 days for the first and last tests.

As stated above, the results of these tests are still preliminary and a determination on our original hypothesis cannot be made until all the data are fully analyzed.


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