ORBITAL SPECTROSCOPY OF THE SURFACE OF VENUS. J. Helbert¹, A. Maturilli¹, M. D. Dyar²,³, S. Ferrari⁴, N. Müller⁵, S. Smrekar⁶, ¹Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (joern.helbert@dlr.de), ² Planetary Science Institute, 1700 East Fort Lowell, Tucson, AZ 85719, ³ Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075, ⁴Dept. of Earth and Environmental Sciences, University of Pavia, Via Ferrata 1 - 27100 Pavia, Italy, ⁵Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena CA, 91109.

Introduction: Many efforts have been made since the landing of Venera 9 and 10 [1] to obtain optical spectra of Venus analog materials at relevant temperatures. Pieters et al. [2] provided a first set of reflectance measurements of basaltic materials in the spectral range from 0.4-0.8 μm. Since then, all efforts, especially to extend these measurements to longer wavelengths, have stalled.

It was commonly accepted that compositional data could only be obtained by landed missions because the permanent cloud cover of Venus prohibits observation of the surface with traditional imaging techniques over most of the visible spectral range. Venus' CO₂ atmosphere is however transparent in small spectral windows near 1 μm. Ground observers have successfully used these windows during the flyby of the Galileo mission at Jupiter; most recently the VMC and VIRTIS instruments on the ESA VenusExpress spacecraft have exploited them. Especially the latter observations have revealed compositional variations correlated with geological features [3-8].

These new observations refute the preset notion that landed missions are needed to obtain mineralogical information. However, interpretations of mineralogy using VNIR spectroscopy data from orbiters requires spectral libraries acquired under conditions matching those on the surfaces being studied.

The Planetary Spectroscopy Laboratory (PSL) at DLR took up this challenge. PSL built on nearly a decade of experience in high temperature emission spectroscopy in the mid-infrared [9-11]. After several years of development and extensive testing, PSL now has a setup in routine operations for Venus analog emissivity measurements from 0.7 to 1.5 μm over the whole Venus surface temperature range.

PSL has started a database of Venus analogs obtaining measurements of samples covering a range from felsic to mafic samples [12]. This first set already shows the potential in the 21st century for mapping of Venus mineralogy and chemistry in situ from orbit with six-window VNIR spectroscopy [13, 14].

The Venus facility at PSL has been open since the summer of 2017 to the community through the Europlanet Research Infrastructure (http://www.europlanet-2020-ri.eu/).

The Planetary Spectroscopy Laboratory (PSL): This project builds on several years of development at DLR [11, 13]. Funding from the European Union as part of the EuroPlanetRI consortium has supported this development – especially the extension of spectral coverage for high temperature measurements down to 0.7 μm.

PSL is located in a temperature-controlled room at the Institute for Planetary Research in Berlin. Two Bruker Vertex 80V spectrometers are located on an optical table equipped with external chambers for emissivity measurements (Figure 1). A recently upgraded Vertex 80V is optimized for the near to far-infrared spectral range.

For near to far-infrared emission spectroscopy (3-100 μm), a high-temperature chamber is attached to the upgraded Vertex 80V. It allows heating of samples to temperatures up to 1000K under medium vacuum conditions (~10-100Pa) [10, 11]. Samples are placed in steel cups equipped with type K thermocouples as temperature sensors. A copper induction coil installed in the chamber is connected to a Lintherm 1.5kW induction system to permit contactless heating of the ferromagnetic sample cups by induction. The induction systems heats the complete sample cup to the same temperature, thereby effectively suppressing thermal gradients in the sample material. For the mid-infrared, spectral coverage is achieved using a combination of a liquid nitrogen-cooled MCT detector and KBr beamsplitter for the spectral range up to 16 μm and a DTGS detector with a multilayer beamsplitter for the remaining spectral range.

Venus configuration: Measuring emissivity at 1
μm at Venus analog temperatures is very challenging for a variety of reasons. Even at Venus surface temperature, emission at 1 μm is relatively low. At the same time, many natural materials have a high transparency at 1 μm. This required the development of new protocols and equipment for these measurements.

PSL developed over the past four years the necessary concepts and protocols for Venus measurements. Euro-PlanetRI (grant number 654208) funding supported implementation of the necessary upgrades, including optimization of the optical layout in the chamber. Upgrading the spectrometer electronics and switching to an InGaAs detector provide a further increase in sensitivity in the range around 1μm, supporting PSL’s focus (from inception) on obtaining high signal-to-noise measurements.

The stainless steel sample holders needed for the induction heating system created an additional challenge. The emissivity of stainless steel increases strongly toward shorter wavelength at high temperatures. This results in a non-negligible contribution to total radiance from our sample cups. To address this issue, we developed a ceramic enclosure (Figure 2) for the stainless steel that suppresses radiation from the sample cups. We used a ceramic with high thermal conductivity so that the sides of the sample cup reach the same temperature as the bottom.

Conclusion: After extensive testing, the new setup at PSL for Venus analog measurements has been demonstrated to perform following our requirements. It is stable and produces reproducibility results. The facility is now open for the community and interested researcher can apply for the currently open call until March 1st 2018 on http://www.europlanet-2020-ri.eu/


Acknowledgment: Europlanet 2020 RI has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 654208.