The Spectroscopy of the surface of Venus. J. Helbert[1], A. Maturilli[1], M. D. Dyar[2,3], S. Ferrari[4,1], N. Müller[5], S. Smrekar[5], [1]Institute 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, [4] Center of Studies and Activities for Space (CISAS) G. Colombo, University of Padova, Via Venezia 15, 35131 Padova, Italy, [5]Jet 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 to 0.8 µm. Since then, all efforts to extend these measurements to longer wavelengths have stalled.

It was commonly accepted that compositional data could only be obtained by landed missions because Venus' permanent cloud cover prohibits observation of the surface with traditional imaging techniques over most of the visible spectral range. Fortuitously, Venus' CO_2 atmosphere is actually transparent in small spectral windows near 1 µm. Ground observers have used these windows to obtain limited spectra of Venus' surface during a flyby of the Galileo mission at Jupiter, and from the VMC and VIRTIS instruments on the ESA VenusExpress spacecraft. In particular, the latter observations have revealed compositional variations correlated with geological features [3-8].

These new observations challenged the present notion that landed missions are needed to obtain mineralogical information. However any interpretation in terms of mineralogy of VNIR spectroscopy data from orbiters requires spectral libraries acquired under conditions matching those on the surfaces being studied.

Venus facility at PSL: The Planetary Spectroscopy Laboratory (PSL) at DLR took up this challenge, building 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 operation 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 analog spectra including measurements of rock and mineral samples covering a range from felsic to mafic rock and mineral samples [12]. This first set already shows the potential for mapping of Venus mineralogy and chemistry *in situ* from orbit with six-window VNIR spectroscopy [13,14,15].

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

Laboratory challenges: Measuring emissivity at 1 µm at Venus analog temperatures is very challenging for a variety of reasons. Even at Venus' surface temperature, emission at 1µm is relatively low. At the same time, many natural materials have high transparency at 1 µm, requiring development of new protocols and equipment for these measurements. The setup at PSL was from inception focused on obtaining high signal-to-noise measurements. Recent upgrades to the spectrometer electronics and a switch to an InGaAs detector provided further increases in sensitivity in 1µm range. New measurement equipment including ceramic sample holders have helped surpress background radiation.

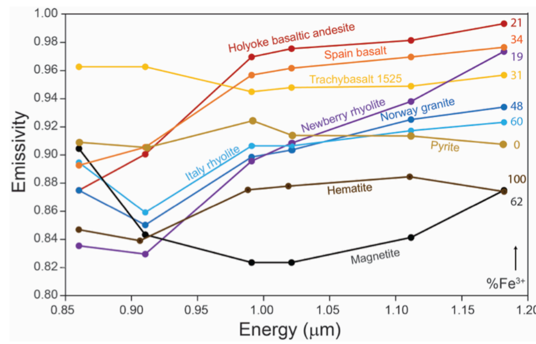

Figure 1. Spectra of Venus analog sample at all known atmospheric surface windows of Venus. Samples represent a suite of crustal differentiation and thus different Fe and Si concentrations. Additional spectral analysis techniques allow for robust identification of subtle spectral differences [13,14,15].

Conclusion: After extensive testing, the new setup at PSL for Venus analog measurements obtains precise spectra for a wide range of samples. It is stable and produces reproducibility results. Therefore, we froze the design at the end of 2016 as our standard set-up for emissivity measurements of Venus-analogue samples in the visible spectral range.

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