



# The Venus surface emissivity mapper on the NASA VERITAS mission and the VenSpec suite on the ESA EnVision mission

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**The Venus surface emissivity mapper on the NASA VERITAS mission and the VenSpec suite on the ESA EnVision mission.** J. Helbert<sup>1</sup>, M.D. Dyar<sup>2,3</sup>, A. C. Vandaele<sup>4</sup>, E. Marcq<sup>5</sup>, N. Mueller<sup>1</sup>, G. Alemanno<sup>1</sup>, A. Maturilli<sup>1</sup>, T. Widemann<sup>6</sup> and S. E. Smrekar<sup>7</sup>, <sup>1</sup>Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (joern.helbert@dlr.de), <sup>2</sup>Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075, <sup>3</sup>Planetary Science Institute, Tucson, AZ, 85719, <sup>4</sup>BIRA, Brussels, Belgium, <sup>5</sup>LATMOS, Paris, France, <sup>6</sup>LESIA, Paris, France, <sup>7</sup>Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109.

**Introduction:** All three recently selected Venus missions include instruments focused on the 1  $\mu\text{m}$  region in their payloads [1]. The NASA VERITAS and ESA EnVision missions use the Venus Emissivity Mapper (VEM) as a multi-spectral imaging system [2, 3]. Building upon the successes of the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on Venus Express, VEM is specifically designed for global mapping of the surface in all available spectral windows. On EnVision, VEM is part of the VenSpec suite as VenSpec-M, joined by a high-resolution IR spectrometer (VenSpec-H) and an UV spectrometer (VenSpec-U). Data from the VenSpec suite will provide unique insights into the coupled surface-atmosphere system [3]. The DAVINCI mission has a descent imager that will also obtain images of the surface in the 1  $\mu\text{m}$  region.

**Emissivity measurements at PSL:** Interpreting emissivity spectra from the Venus surface requires new laboratory calibration of high-temperature samples. Bi-directional reflectance data that are typically available in other spectral libraries are not useful for calibration of emissivity measurements, even at high temperatures, because they do not sample all possible angles of incidence and reflectance [4]. However, hemispherical reflectance measurements at high temperatures have been shown to be similar to emissivity [4]. The Planetary Spectroscopy Laboratory (PSL) at DLR in Berlin now routinely measures emissivity spectra of planetary analogues at temperatures up to 1000K in a vacuum (0.7 mbar) environment. Initially focusing on the MIR and TIR for Mars and Mercury mission support, the system has been fine-tuned over ten years to obtain VNIR emissivity spectra at relevant Venus surface temperatures (400°C, 440°C, and 480°C).

The Venus emissivity setup [5-7] is now in routine operation and available to the community via the Europlanet Research Infrastructure as part of the Distributed Planetary Lab Facilities (<https://www.europlanet-society.org/europlanet-2024-ri/ta2-dplf/>) (see [2] for PSL details).

**Rock type mapping with VEM:** At PSL, we have to date measured the emissivity of more than 100 rock samples under Venus surface conditions. Figure 1 shows that the VEM instrument on VERITAS can easily distinguish between basaltic and felsic rock types with given the predicted VEM performance. The required

performance of 4% relative emissivity is significantly smaller than the observed emissivity contrast between basalt and granite/rhyolite in the laboratory, even taking into account likely grain size variations on Venus [5] as well as natural variability in the samples. VenSpec-M on EnVision using the VERITAS derived topography will now be able to achieve the same performance, highlighting the synergies of the two missions. Combining the surface mapping from VEM on VERITAS and VenSpec-M on EnVision will allow to look for change, as well as guarantee a full coverage of the planet. This will be complemented by the 1 micron observations of the DAVINCI descent camera system.

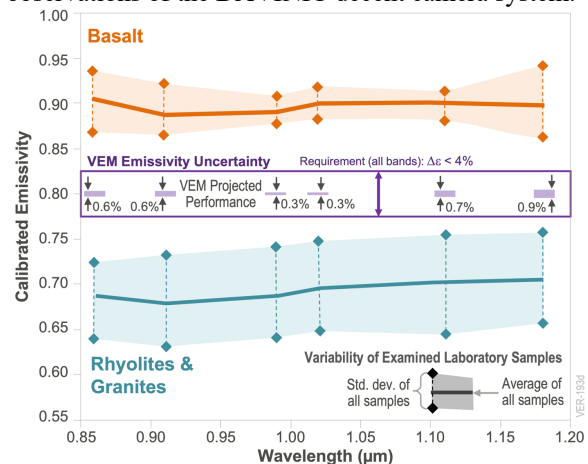


Figure 1. Predicted performance of VEM on the NASA VERITAS mission will allow to distinguish between mafic and granitic rock types as well as identify intermediate rock types

**VEM verification:** The Venus chamber at PSL is equipped with an NIR transparent window that allows the VEM instrument to be mounted for measurements of Venus-analog samples at appropriate surface temperatures (Figure 2). This capability has been invaluable during the VEM development phase.

VEM uses onboard software developed for MERTIS to bin, co-add, and losslessly compress data upon uplink command. During the science phase, VEM oversamples at 10 km spatial resolution (33×33 pixel binning). To further enhance SNR, VEM co-adds shifted frames to provide 189× gain over the single-pixel SNR. Taking the current performance of the laboratory prototype in PSL for a single unbinned exposure and the expected SNR enhancement due to onboard processing, we

expect a system SNR of well beyond 1000 which translates to a predicted error in the retrieval of relative emissivity of better than 1% [2].

The PSL setup will be used extensively in the calibration campaign for the flight instruments for VERITAS and Envision.



Figure 2. The VEM prototype during measurements at PSL to verify the instrument performance using Venus analogs at Venus surface temperatures

**Active volcanism:** VEM on VERITAS and VenSpec-M on Envision will also search for the chemical/thermal signature of recent/active volcanism. The long temporal baseline provided by VERITAS and EnVision enhances the probability that changes caused by active volcanism will be detected. In addition, using additional filter centered on water vapor bands the instruments will allow to detect enhanced water vapor abundance close to the surface to be mapped as another indicator for active volcanism.

**The VenSpec on Envision:** The VenSpec suite [3] consists of three channels: VenSpec-M, VenSpec-H and VenSpec-U. VenSpec-M will provide near-global compositional data on rock types, weathering, and crustal evolution by mapping the Venus surface in the using the same filter as VEM on VERITAS. VenSpec-H will be dedicated to extremely high-resolution atmospheric measurements. The VenSpec-H instrument will detect and quantify  $\text{SO}_2$ ,  $\text{H}_2\text{O}$  and  $\text{HDO}$  in the lower atmosphere, enabling characterization of volcanic plumes and other sources of gas exchange with the surface of Venus. The data will also complement VenSAR and VenSpec-M surface and SRS subsurface observations. VenSpec-U will monitor sulphured minor species (mainly  $\text{SO}$  and  $\text{SO}_2$ ) and the as yet unknown UV absorber in Venusian upper clouds and just above.

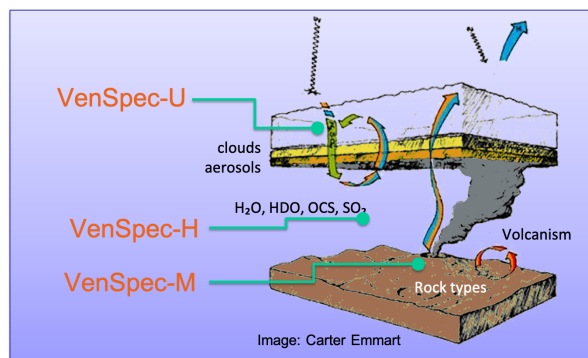


Figure 3. The VenSpec suite on Envision will provide unprecedented insights into the current state of Venus and its past evolution.

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