Abstract #8022

The VNIR emissivity spectra of Venus analogue rocks for the interpretation of "the decade of Venus" remote sensing data

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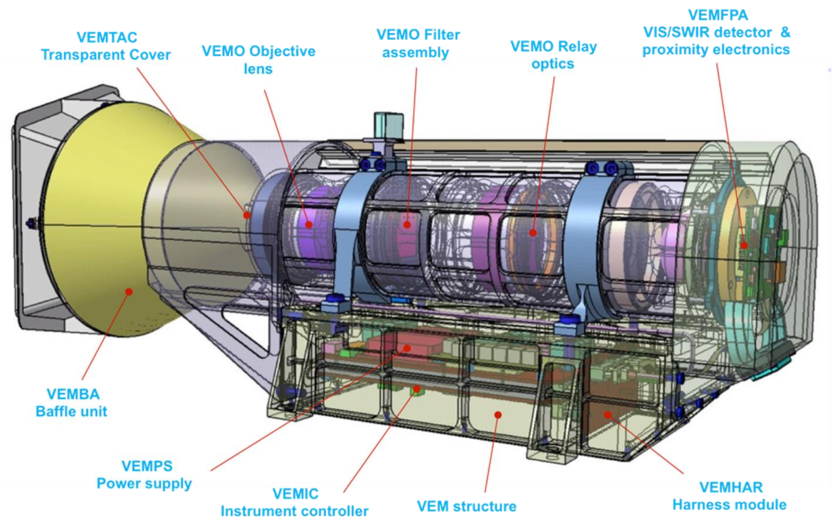
On 2 June 2021, NASA selected 2 missions to Venus ~~as~~ for the next Discovery Program: VERITAS, and DAVINCI. One week later, ESA's SPC selected EnVision as the fifth Medium-class mission in the Agency's Cosmic Vision Program. Both NASA missions are expected to launch in the 2028-2030 timeframe, while ESA is targeting a launch in the early 2030s. With all these space missions targeting the same planet, the 2030s have been renamed as "the decade of Venus". All three recently selected Venus missions include in their payload VNIR instruments focused on the 1 µm region. The NASA VERITAS and ESA EnVision missions use the Venus Emissivity Mapper (VEM) as a multi-spectral imaging system. VEM is specifically designed for global mapping of the surface in all available spectral windows. The DAVINCI mission has a descent imager that will also obtain images of the surface in the 1 µm region.

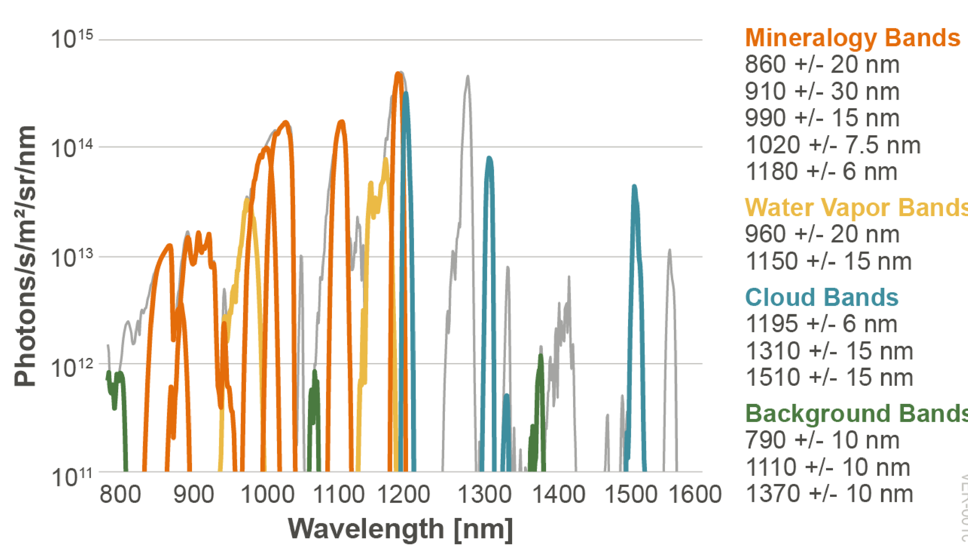
Venus Surface: Previously, it was commonly accepted that spectra could only be obtained by landed missions because Venus' permanent cloud cover prohibits observation of the surface with traditional imaging techniques. Fortuitously, Venus' CO_2 atmosphere is actually partly transparent in small spectral windows near 1 µm. These windows were used to obtain limited spectra of Venus' surface by ground-based telescope observers, during a flyby of the Galileo mission to Jupiter, and by the VMC and VIRTIS instruments on the ESA Venus Express spacecraft. The latter observations revealed emissivity variations correlated with geological features [1].

VEM on VERITAS and EnVision: VEM is a multi-spectral imager focused on three core tasks: 1) Mapping the surface composition of Venus on a global scale, 2) Monitoring for volcanic activity on Venus, and 3) Mapping the near surface water vapor abundance of Venus. VEM leverages a proven measurement technique pioneered by VIRTIS on Venus Express, but with greatly improved sensitivity and spectral and spatial coverage. VEM is the first instrument designed specifically for mapping the surface of Venus using the near infrared atmospheric windows, with 14 spectral bands covering all 5 surface windows, Oversampling at 10km spatial resolution, and high signal to noise ratio.



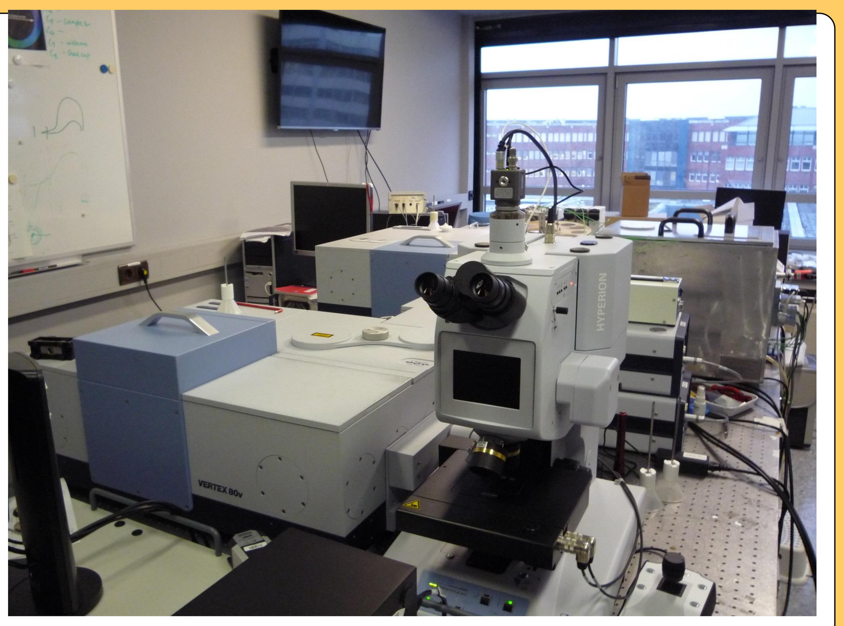
This defines the VEM design

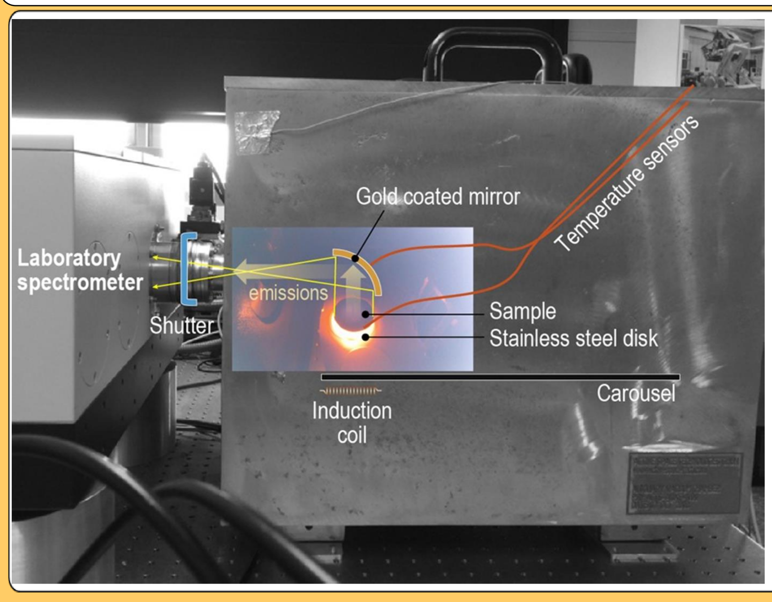
- Surface spectral windows
  - cover spectral windows where radiation from the surface escapes
  - Have a wavelength resolution adapted to the varying width of the windows
- Cloud bands
  - Spectral windows where radiation originates below the clouds but above the surface
  - These bands provide the cloud contrast variation
  - More than one band allows to check (or correct) the grey cloud assumption
- Background bands
  - Radiation from the dayside gets scattered into the nightside
  - More than one band allows assessing whether scatter light has a slope
- Water vapor
  - Sensitive indicator for volcanic activity
  - Variations in near surface water vapor abundance might mimic variations in surface composition

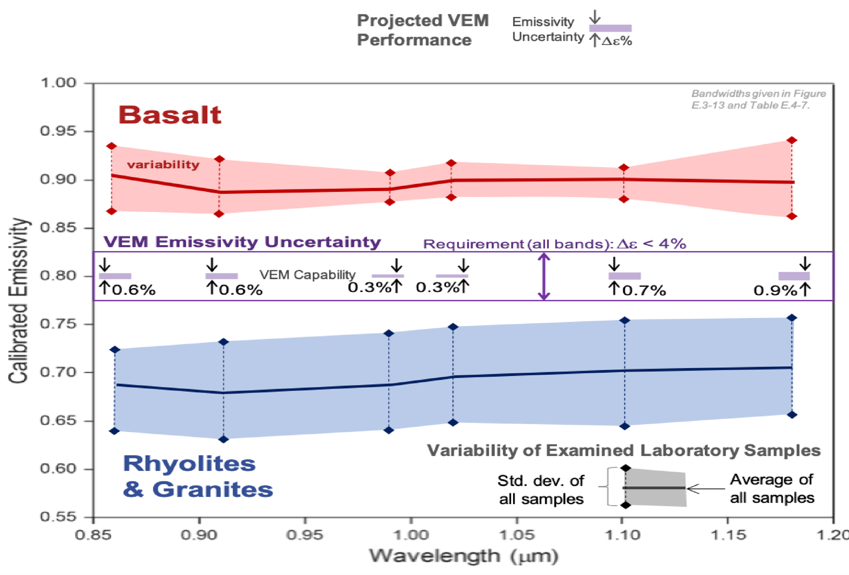


Purpose	Mineralogy						Clouds			Water	
Wavelength	860	910	990	1020	1110	1180	1195	1310	1510	960	1150
Width	40	60	30	15	20	12	12	30	30	40	30
SNR	53	53	44	43	145	125	134	134	134	100	100

Emissivity set-up at PSL: The Planetary Spectroscopy Laboratory (PSL) of 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 MIR+TIR for Mars and Mercury mission support, we started almost 10 years ago to fine-tune the set-up to obtain VNIR emissivity spectra at relevant Venus surface temperatures (400° C, 440° C, and 480° C) by means of very powerful induction system allows heating our custom-made sample cups. To avoid glowing of steel in the VNIR at those temperatures, we choose incapsulating a steel disk (the heater) in a ceramic sample holder. The hot ceramic is opaque in the VNIR and its emitted radiance is very low (see [2] for PSL details).







[1] Helbert J. et al. (2008) GRL 35, 11, 1-5.
[2] Helbert J. et al. (2020) Sci. Adv., 7, 3.

At PSL, we have to date measured the emissivity of almost 100 rock samples under Venus surface conditions. Figure above shows that basaltic and felsic rock types can easily be distinguished with relative emissivity data. With absolute emissivity at six windows, further distinctions can be made along the igneous differentiation trend. These emissivity measurements are needed to interpret Venus surface data because significant errors can arise from using bi-directional reflectance measurements (as shown in the first figure on the right). The second figure shows the good agreement of our lab data with Venera lander measurements.