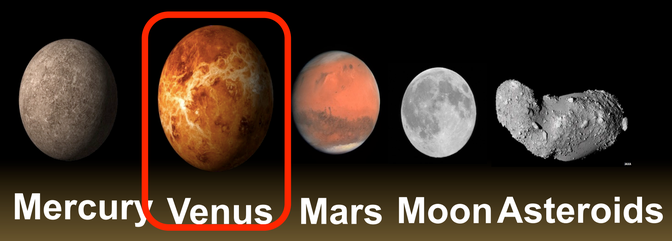

The Spectroscopy of the surface of Venus

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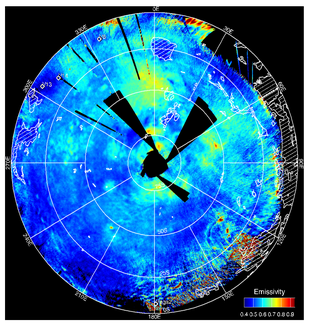
DLR has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208

Abstract

Many efforts have been made since the landing of Venera 9 and 10 to obtain optical spectra of Venus analog materials at relevant temperatures. Pieters et al. (1986) 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 can only be obtained by landed mission because the permanent cloud cover of Venus prohibits observation of the surface with traditional imaging techniques over most of the visible spectral range. Venus' CO_2 atmosphere is only transparent in small spectral windows near 1 mm. Ground observers have successfully used these, during the flyby of the Galileo mission at Jupiter, and most recently by the VMC and VIRTIS instruments on the ESA VenusExpress spacecraft. Especially the latter observations have revealed compositional variations correlated with geological features.

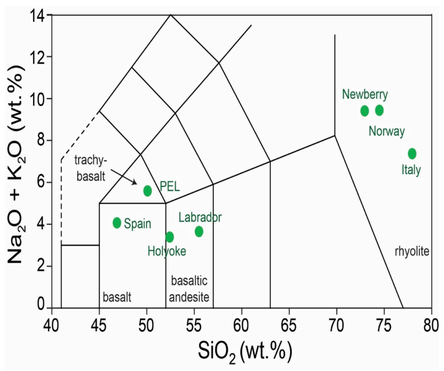
These new observations challenged the preset notion that landed missions are needed to obtain mineralogical information. However any interpretation in terms of mineralogy of VNIR spectroscopy data from orbiters requires spectral libraries acquired under conditions matching those on the surfaces being studied. Planetary Spectroscopy Laboratory (PSL) at DLR now has a setup in routine operations for Venus analog measurements in emissivity from 0.7 to 1.5µm 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. 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

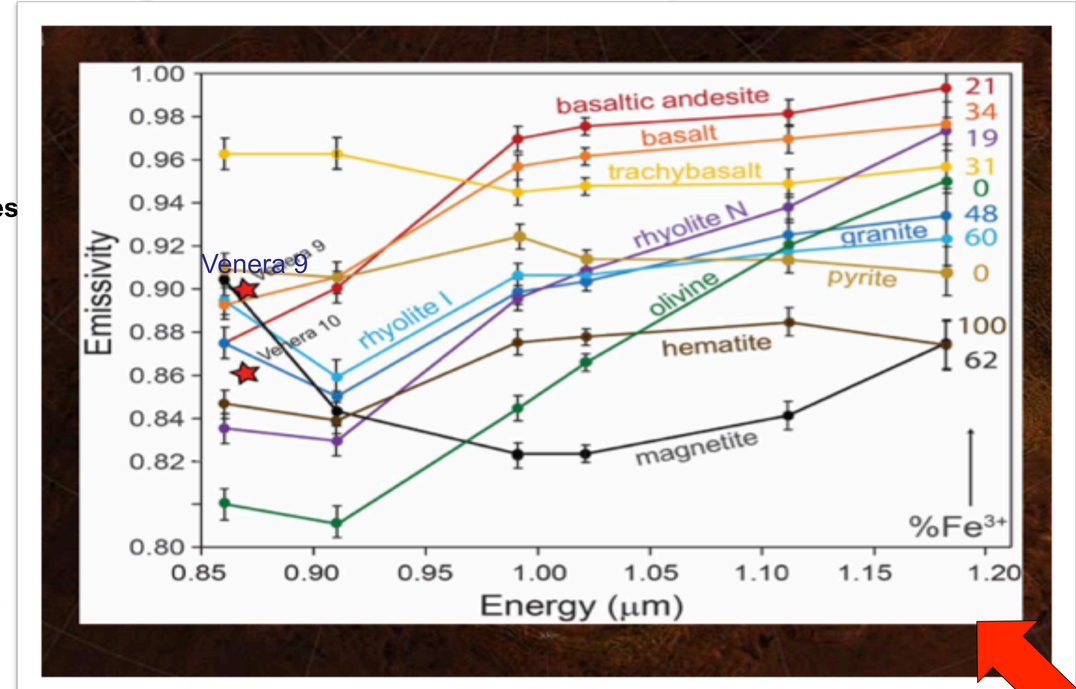


Müller et al. 2008, Helbert et al. 2008

Emissivity of Venus analogs at 480°C for all atmospheric windows

This set of Venus analog samples covers the range of expected mineralogies for Venus. The set represents the start of a Venus analogs database. Suggestions for additional samples are always welcome!



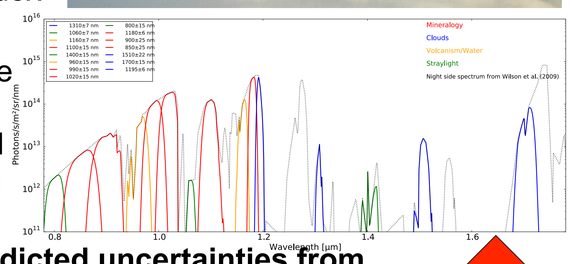


The Venus Emissivity Mapper (VEM)

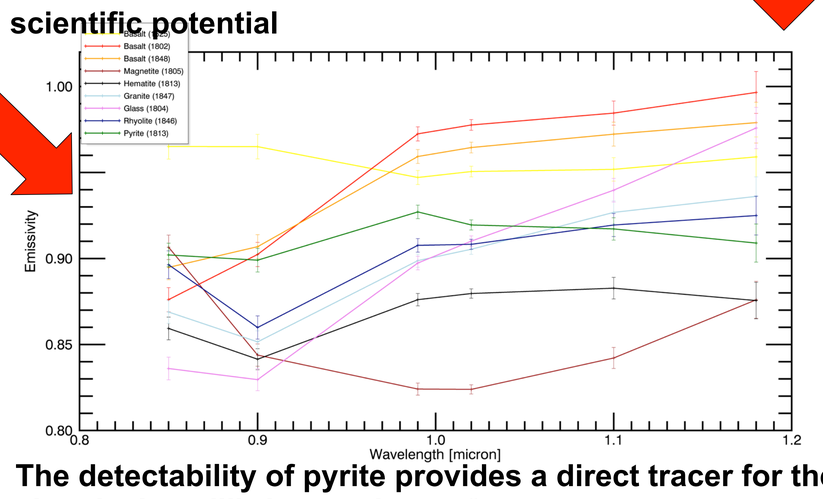
VEM leverages a proven measurement technique pioneered by VIRTIS on VEX and strong heritage from MERTIS

VEM will

- have greatly improved sensitivity and spectral and spatial coverage
- provide global surface composition and redox state of the surface
- address atmosphere surface interaction, cloud dynamics and volcanic outgassing



Emissivity with predicted uncertainties from system and atmospheric effects using a full RTM for VEM nominal observations shows the scientific potential



The detectability of pyrite provides a direct tracer for the chemical equilibrium at the surface

$3FeS_2 + 16\ CO_2 \rightleftharpoons Fe_3O_4 + 6SO_2 + 16CO$

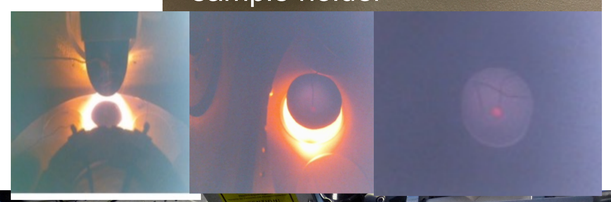
- VEM development model includes flight optics and detector with simplifed filter array (2 out of 14 filters)
- First VEM performance testing conducted

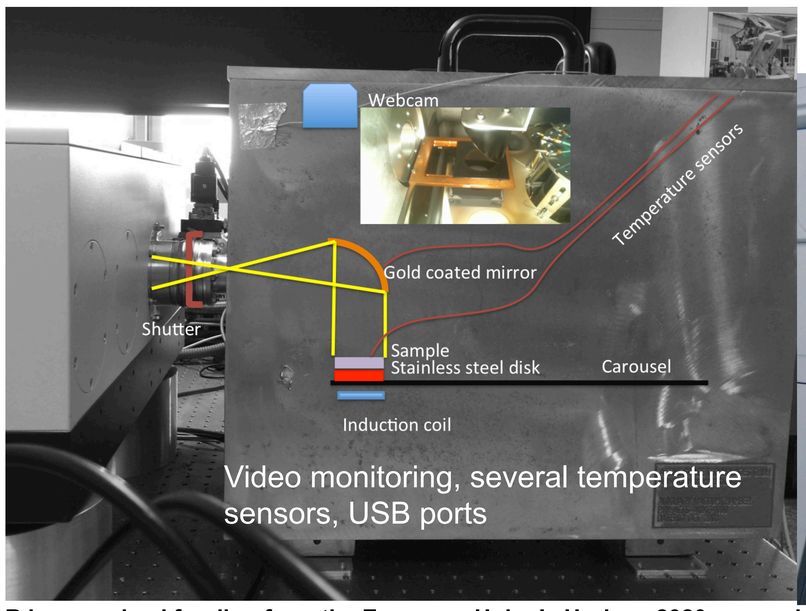
- Uncertainty from a single pixel measurement is <0.35%
- **This translates to a VEM SNR > 1000 for nominal operations incl. TDI and binning**

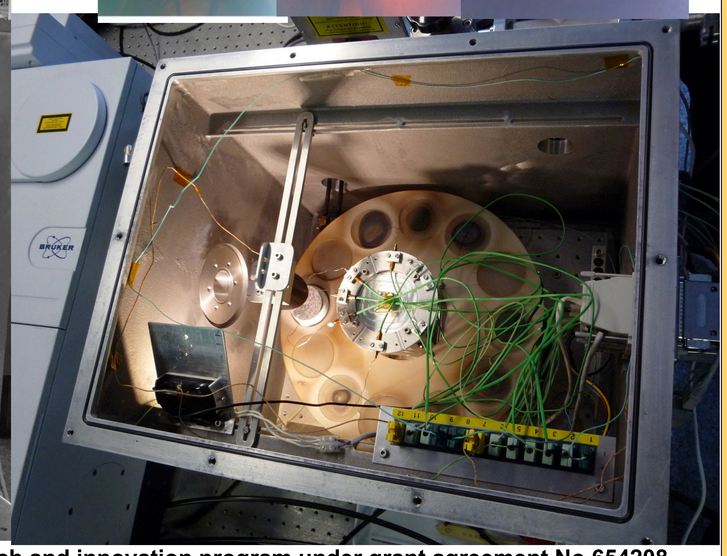
Measuring Venus analogs at PSL

PSL is the only facility in the world able to measure the emissivity of Venus analogs in the wavelength range at Venus surface temperatures covering all atmospheric windows.

- Spectral coverage 0.7-16 µm
- Temperature range 0-700˚C
- Particulate and solid samples
- Visual monitoring of samples during heating
- Recently upgraded with funds from EU eurPLANET







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