The Venus surface emissivity mapper on the NASA VERITAS and ESA EnVision missions

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Contents of abstract: All three recently selected Venus missions include in their payload 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. 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). The data of the VenSpec suite will provide us unique insights into the coupled surface-atmosphere system. The DAVINCI mission has a descent imager that will also obtain images of the surface in the 1 μm region.

VIRTIS data yielded groundbreaking insights into relative emissivity of tesserae and recent volcanism with just two bands. We now explore how much additional information is contained in the six possible bands within the spectral windows between 0.86 and 1.18 μm. A dedicated effort to set up a new Venus high temperature spectroscopy laboratory enables development of a spectral library to fully support this investigation.

Emissivity set-up at PSL: Interpreting emissivity spectra from the Venus surface requires laboratory calibration of high-temperature samples. 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 the MIR and TIR for Mars and Mercury mission support, we started almost 10 years ago to fine-tune our set-up to obtain VNIR emissivity spectra at relevant Venus surface temperatures (400°C, 440°C, and 480°C). Using a very powerful induction heating system, our sample cups were initially made of stainless steel. Unfortunately, the emissivity of steel is so high in the VNIR spectral range that the sample cups glowed at those elevated temperatures, exceeding the emitted energy coming from the sample alone. After trying several materials, we ended with 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).

VNIR emissivity of rock analogues: At PSL, we have to date measured the emissivity of almost 100 rock samples under Venus surface conditions. Figure 1 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. However, direct emissivity measurements are needed to interpret Venus surface data, because significant errors can arise from using bi-directional reflectance measurements (as shown in Figure 2 for 2 slabs in the MIR spectral range).

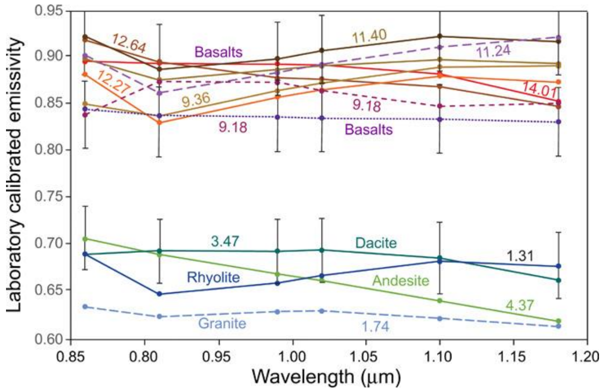

Fig. 1. Emissivity data down-sampled to VEM filters.

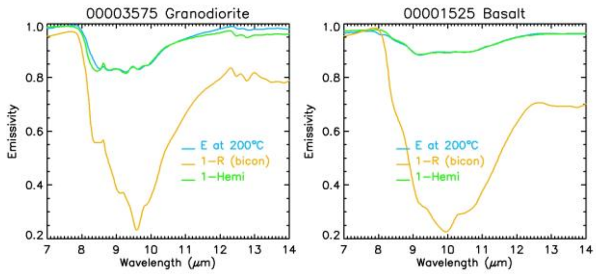

Fig. 2. Emissivity vs Bi-directional and Hemispherical reflectance for the same 2 slab samples.

Surface mapping with VEM: This recent laboratory data show that emissivity measurements through windows observed with high SNR can leverage information from spectral slopes between bands and band ratios. For VEM's six bands, there are 15 possible combinations of each, adding 30 different values for interpretation. Our analyses show 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.

References: . [2] Helbert J. et al. (2020) *Sci. Adv., 7, 3*.