THE VNIR EMISSIVITY SPECTRA OF VENUS ANALOGUE ROCKS FOR THE INTERPRETATION OF "THE DECADE OF VENUS" REMOTE SENSING DATA.

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Introduction: On 2 June 2021, NASA selected two missions to Venus as part of the next Discovery Program: VERITAS, and DAVINCI. One week later, ESA's Science Programme Committee 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 compositional data 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 from the VMC and VIRTIS instruments on the ESA Venus Express spacecraft. The latter observations revealed compositional variations correlated with geological features [1].

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).
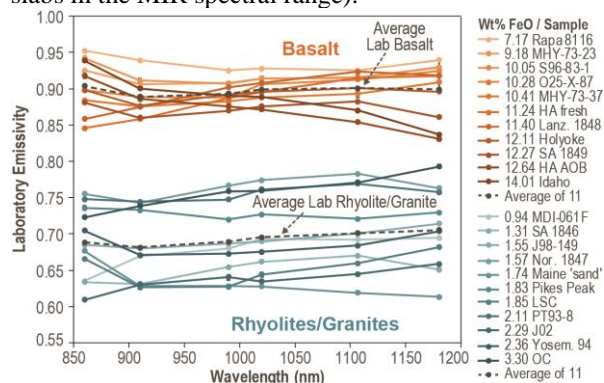

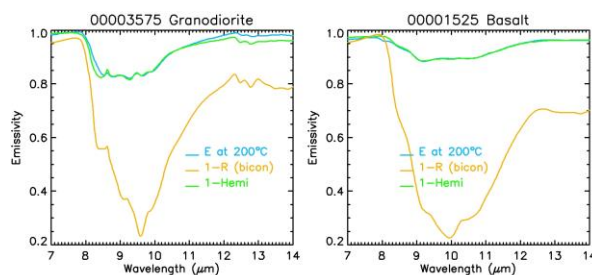Fig. 1. Emissivity data down-sampled to VEM filters.

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

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