THE VENUS EMISSIVITY MAPPER (VEM) PROTOTYPE. D. Wendler[1], J. Helbert[1], I. Walter[2], T. Widemann[3], G. Guignan[4], E. Marcq[4], A. Maturilli[1], S. Ferrari[5,1], M. D'Amore[1], N. Müller[6], M. D. Dyar[7], and S. Smrekar[6], [1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (dennis.wendler@dlr.de), [2]Institute for Optical Sensorsystems, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany, [3]LESIA, [4]LATMOS, [5]Department of Earth and Environmental Sciences, University of Pavia, Via Ferrata 1 - 27100 Pavia, Italy, [6]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena CA, 91109, Planetary Science Institute, 1700 East Fort Lowell, Tucson, AZ 85719.

The Venus Emissivity Mapper (VEM) is a multispectral imager in the visible and near infrared spectra, operated between 0.79 and 1.51µm. The instrument recently completed a Phase A study for the NASA Discovery VERITAS proposal [1]. VEM is a push broom camera meant to be operated in an orbit altitude above 200km on the Venus night side to map the surface composition. As the Venus atmosphere is opaque in the visible spectra, surface observations are typically only be obtained with radar missions, which can provide only very limited information on the surface material or composition.

With VIRTIS on the VenusExpress mission we used for first time from orbit narrow spectral windows located around 1µm to map the southern hemisphere of Venus [2,3]. As VIRTIS was not build for this purpose, there were mainly challenges however it provided a proof-of-concept. VEM is specifically built to observe the surface using all known atmospheric windows. This allows to map surface mineralogy on a global scale [4,5]. The design of VEM can be seen in Figure 1.

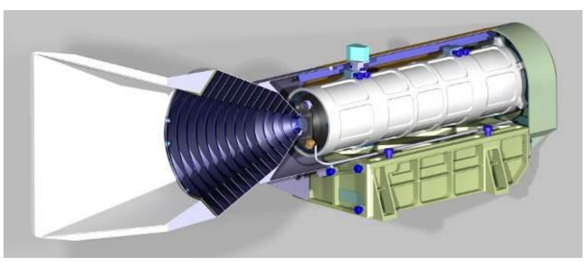

Figure 1. VEM FM Design.

VEM design: The camera design is optimized to reduce potential risks while maximizing the scientific return. The multi vane baffle prevents stray light and spacecraft glints from entering into the optic. The VEM optic (VEMO) consists of three lenses and a filter array consisting of 14 narrow bands located between 0.79 and 1.51µm. The field of view of 46 degrees is a direct result of the objective to cover the whole Venus surface in a reasonable mission duration as well as the altitude of the mission and the slow Venus rotation. As result, a lens instead of a mirror design is used. As a positive effect, overlapping images on consecutive flyovers increase the signal on each target area. Furthermore, a hinged cover protects the optic from contamination during flight. The used Indium-Gallium-Arsenide-detector is perfectly suited for the infrared spectra and is already space proven. The electronics, software and structural design are directly inherited from MERTIS, part of the ESA mission BepiColombo.

Laboratory Prototype: To prove the capabilities of the proposed camera, a laboratory prototype (LP) has been built, following an earlier VEM breadboard [6]. The LP is representing a simplified version of the VEM flight model (FM) by using only the optics and the detector. Figure 2 shows the opened LP.

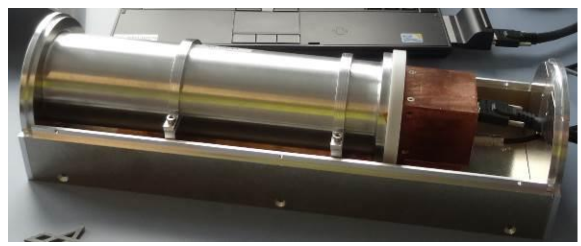

Figure 2. Opened VEM laboratory prototype with VEMO and OEM module detector in copper housing.

The LP is using an OEM module of the proposed flight detector while the filter array consist of two bands, located at 865nm as well as 1381nm, one transparent window and masked areas.

LP @ PEL: After the assembly and first test phase, the LP has been taken into the laboratory to be tested at the DLR Planetary Emissivity Laboratory (PEL) in Berlin. The PEL can heat minerals on Venus surface temperature levels and measure the spectrum [4]. The LP can be mounted on the PEL and observe the probes through a window to take the images. Figure 3 shows the test setup at the PEL with the LP looking downward onto the heated probe.

Figure 3. The LP located on top of the PEL looking downward on heated probes.

The PEL has already started generating a database of minerals, which can be used for comparison with the LP images to be able to evaluate the performance [2].

Test conditions @ PEL: A newly developed sample cup minimized the effect of visible radiation from the hot sample holder, but is not yet available for granulated minerals [2]. Figure 4 is shows the improvement achieved with the new sample holder.

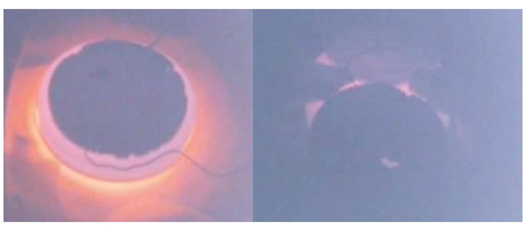

Figure 4. Steel plate @ 440°C caused stray light problems for VEM (left) with the new fully encapsuled plate this issue is mitigated (right).

Different slab samples shown in Figure 5, a basalt-calcite combination and a blackbody-quartz combination, have been measured. All slabs have been heated and measured at different temperature levels, and VEM images have been taken.

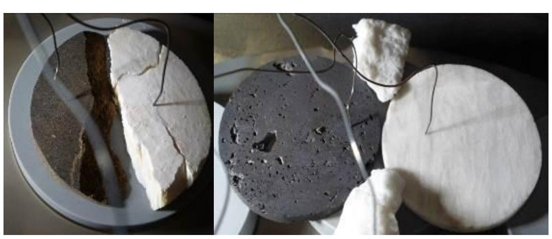

Figure 5. Mineral samples for the LP test; Left: Basalt-Calcite slab, Right: Blackbody-Quartz slab.

LP capabilities: Currently the LP is used to optimize the image quality. Figure 6 shows images taken with a first test configuration.

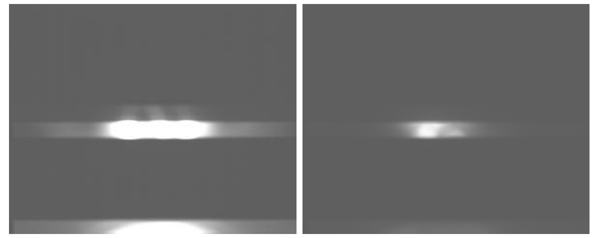

Figure 6. LP images @ 440°C; Left: Signal in the 1381nm band located in the middle (top), Right: Signal in the 865nm band.

Additionally, the analysis algorithm is still in development, so that the analysis is currently manual. The evaluation is still ongoing and will be completed within the next months.

Conclusion: To advance the capabilities of the LP, the process of testing and the camera will be further developed. The algorithm is undergoing constantly improvements to increase the gain on the images as well as to automate the post-processing.

Based on the ongoing analysis of the taken images, the test setup will be further optimized with a special focus on minimizing the thermal influence. Additionally, a broader variety of minerals in different grain sizes needs to be examined with the newly developed cups.

As a next development step towards an Engineering Prototype a filter array with all 14 bands will be implemented.

Using the unique laboratory facilities at PSL allows to evaluate the performance of the VEM concept, test design modifications and prove the VEM concept. The same setup will be used as part of the VEM calibration process.

References: [1] Smrekar S. et al. (2016) LPSC. [2] Mueller, N., J. Helbert, G. L. Hashimoto, C. C. C. Tsang, S. Erard, G. Piccioni and P. Drossart (2008). Journal of Geophysical Research 113 [3] Helbert, J., N. Müller, P. Kostama, L. Marinangeli, G. Piccioni and P. Drossart (2008). Geophysical Research Letters 35(11). [4] Helbert J. et al. (2017) this meeting. [5] Dyar M. et al. (2017) this meeting. [6] Wendler D. et al (2015) http://elib.dlr.de/101033/.