Laboratory VNIR emissivity spectra of Venus analogue rocks for EnVision and VERITAS and the VenSpec-M/VEM verification plan

G. Alemanno[1], J. Helbert[1], A. Maturilli[1], M. D. Dyar[2,3], S. Adeli[1], A. Van Den Neucker[1], S. Smrekar[4]

[1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (giulia.alemanno@dlr.de)
[2]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075
[3]Planetary Science Institute, Tucson, AZ, 85719
[4] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena CA, 91109 (USA)

Abstract

The Venus Emissivity Mapper (VEM) on the VERITAS mission and the VenSpec-M on the ESA EnVision mission are similar multi-spectral imaging systems designed specifically for mapping the surface of Venus using the near infrared atmospheric windows around 1 µm. VEM/VenSpec-M will provide the first global map of rock types on the surface of Venus as well as constant monitoring for volcanic activity at global (VERITAS) and regional/local (EnVision) scales. To correctly interpret VEM/VenSpec-M data and map the Venus surface composition, a proper data verification plan is needed. We outline here a basic plan that not only provides fundamental data needed for VEM and VenSpec-M, but can also be adapted to create data products suitable for calibration of the VenDi (Venus Descent Imager) instrument on the DAVINCI mission. Such use of an integrated calibration plan will benefit all three missions and produce coordinated results that can be directly compared.
The VEM/VenSpec-M verification plan is based on the following steps:
1. Creation of spectral library. To date, at PSL (Planetary Spectroscopy Laboratory at DLR in Berlin [1]) we measured the emissivity of more than 100 rock samples under Venus surface conditions. Based on those measurements, we are confident that the six bands measured by VEM/VenSpec-M will have the capability to distinguish basalt from granite [2] given the predicted performance [3]. It is likely that distinction of intermediate compositions will be possible based on their iron contents. In support of that effort, the spectroscopy verification plan will create several spectral increasingly complex libraries: - The **minimal** database needed to serve the requirement to distinguish basalt vs. granite and to address weathering/coating requires at least 250 samples; - The **basic** database (approx. 500-1000 samples) is needed to span intermediate compositions and characterize mineral phases, mixtures of rock types (quarters), and minerals (particulates); - An **extended** database will contain hypothesis-driven samples (e.g., metallic snow) in keeping with ongoing research questions; - Finally, we expect to add spectra from samples contributed by the Venus **community**. Essential to this endeavour are field campaigns in Venus analogue sites [4] and a variety of close collaboration with research institutes around the world.
2. Calibration using flight models and qualification instrument models. The Venus chamber at PSL is equipped with a NIR transparent window that allows the flight instruments to be mounted for measurements of calibration samples at appropriate surface temperatures.
3. Engineering instrument calibration. On-ground and in-flight calibration are foreseen for the orbital instruments. On-ground instrument calibration will include pre-flight geometric, spectral, and radiometric calibrations based on MERTIS calibration campaign and pipeline.
4. Machine learning models. Igneous rocks are typically classified on the basis of chemical information about Na, K, and Si (e.g., the total alkali vs. silica TAS diagram for volcanic rocks). Because those elements are featureless in the 1 µm region, orbital identifications of Venus rock types instead depend upon transition metals (dominantly Fe) that do have spectral features in that region. Therefore, we will train machine learning models to predict FeO using the growing suites of laboratory calibration data collected with the Venus emissivity setup at PSL [5].

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