Probing Rock Type, Iron Redox State, and Transition Metal Contents with 6-Window VNIR Spectroscopy under Venus Conditions

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Motivation

- Orbital VNIR spectroscopy of Venus is hampered by Venus' thick, CO₂-rich atmosphere, though observations are possible through transparent windows in the CO₂ spectrum near 1 μm (below).
- Venus Emissivity Mapper (VEM) was developed for the VERITAS mission to study the surface of Venus through six different windows at 0.86, 0.91, 0.99, 1.02, 1.11, and 1.18 μm.
- Two specific issues are addressed here:
  1. The ability of VEM-window data to distinguish among key rock types on Venus, and
  2. Their capability to evaluate redox state and transition metal contents of Venus surface rocks.

**FILTERS ON VEM** compared against a synthetic Venus night side spectrum (dashed envelope). Red are surface bands, blue bands for cloud correction, green stray light correction and yellow bands to detect water vapor.

**EMISSIVITY DATA** (above) with %Fe³⁺ (left) and wt.% Fe³⁺ (right) indicated as determined by combining Mössbauer, x-ray fluorescence, and electron microprobe, showing two trends:
1. The wavelength region ca. 0.99 and 1.02 μm allows hematite to be distinguished from magnetite, and oxides from silicates. In this region, Fe (and other transition metals in silicate minerals cause elevated emissivity, felsic rocks group separately, and oxides have low emissivities.
2. Even the 1.18 μm band can be used to determine oxidation state and thus infer weathering (below). This distinction is key to understanding surface-atmosphere interactions on Venus.
3. Samples containing Fe oxides (rhylolite, granites, and the oxides themselves) have negative slopes between the two lowest wavelength bands.

**DISCRIMINATING AMONG ROCK TYPES:** A key capability needed for understanding Venus is distinguishing between basalt plains on Venus and other igneous rock types that might occur in continental crust. To model this, we used averages of lab data and interpolated between them using FeO contents (figure at upper right) to obtain model spectra for basaltic andesite, andesite, and dacite. We then randomly applied model errors to create 100 synthetic spectra within a random distribution and parameterized the information contained in the six channels as shown below.

**SUMMARY**

Even with only 6 channels of spectral data, VEM data inform the redox state and chemical composition of Venus’ surface from orbit. Slopes between the lowest two channels and among the highest ones allow information about iron redox state and olivine/pyroxene abundances (=transition metal abundances in those minerals), respectively, to be distinguished. A binary classifier easily separates possible rock types on Venus.

**REFERENCES**