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Laboratory Measurements of Spectral Reflectance of Possible Mercury-analog Materials
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The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [2] on the MESSENGER spacecraft [1] has been observing Mercury from orbit since 29 March 2011 and has obtained more than 1.4 million near-ultraviolet to near-infrared spectra of the Mercury surface during the first ten months of operations. The Visible and Infrared Spectrograph (VIRS) channel on MASCS covers the wavelength range 300-1450 nm. VIRS reflectance spectra have shown no unequivocal evidence of the absorption band centered near 1000 nm wavelength associated with the presence of ferrous iron in silicates. The lack of this absorption and evidence of ultraviolet (UV) absorption shortward of 300 nm is consistent with the possibility of very low iron content (2-4 wt% FeO) [3].

Two key factors that may affect the relative shape (breadth, depth, and band center), and thus the detectability, of subtle bands in reflectance spectra measured by MESSENGER are (1) the viewing geometry of the MASCS observations, (MESSENGER orbital and pointing constraints restrict reflectance observations of Mercury to a phase angle range between 78 and 100 deg., with average incidence and emission angles between 39 and 50 deg.); and (2) the high temperature of the dayside Mercury surface, which can exceed 400 C [4].

Photometric variations affect reflectance properties [e.g., 5,6], which is one reason most laboratory-standard observations are conducted at incidence-emission-phase angles of 30-0-30 deg. Few laboratory observations of relevant materials cover the viewing geometry range to which Mercury observations are restricted. Similarly, high temperatures affect the reflectance properties of soils [e.g., 7,8,9], but few measurements have been conducted at Mercury surface conditions, or of materials likely to be important on Mercury.

We are conducting a pair of related studies at the Brown University Reflectance Laboratory (RELAB) and the optics laboratory of the Applied Physics Laboratory (APL) to understand the effects of photometry and temperature on reflectance spectral properties. At RELAB, we are examining materials (starting with low-iron pyroxenes and komatiites) at a MESSNGER-like range of incidence, emission, and phase angles, from ~350 nm to over 2000 nm with the purpose of providing proper photometric comparisons of known laboratory samples to Mercury observations.

Variation of reflectance with temperature for a given mineral can be wavelength dependent and non-uniform. At APL, we are investigating thermal effects on spectral reflectance of rock-forming minerals from UV through near-infrared wavelengths under vacuum and over a temperature range of -100 to 400 C. Several studies [e.g., 8,9] show that silicate absorption bands tend to widen, shoal, and shift position with increasing temperature. In the near-infrared, the ~1000 nm Fe^{2+} crystal-field absorption bands shift shortward for olivines, and longward for orthopyroxenes. The distorted M2 site 2000 nm absorption bands of orthopyroxenes also shift, though more subtly [7]. In addition, spectral slopes from UV through near-infrared can change, potentially affecting Fe and Ti compositions on Mercury, the Moon, and other solar system materials [10].

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