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Search for Absorption Features in Mercury's Ultraviolet and Visible Reflectance Properties

Faith Vilas (1), Deborah L. Domingue (1), Elizabeth A. Jensen (1), Ann L. Sprague (2), Noam R. Izenberg (3), Jörn Helbert (4), Mario D'Amore (4), and Sean C. Solomon (5)
(1) Planetary Science Institute, Tucson, AZ 85719, USA, fvilas@psi.edu; (2) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA; (3) Johns Hopkins University, Applied Physics Laboratory, Laurel, MD 20723, USA; (4) DLR, Rutherfordstrasse 2, Berlin, Germany; (5) Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA.

Abstract

We discuss a search for the possible presence of absorption features at ultraviolet and visible wavelengths that could be present in surface reflectance data from Mercury collected by the MESSENGER spacecraft. On the basis of terrestrial and lunar studies, potential sources for such features have been identified. Orbital and flyby reflectance data from MESSENGER, categorized by geologic unit, are examined for these potential sources.

1. Introduction

Closest to the Sun, the planet Mercury potentially holds many secrets to the formation conditions and processes that occurred in the inner Solar System. Competing hypotheses regarding Mercury's formation predict different compositions for the crust of this planet. The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft, now in orbit around Mercury, includes many remote sensing instruments designed to address the crustal composition of the innermost planet. Major objectives of this mission include learning about Mercury's geological history and planetary formation conditions, and the influence of infalling meteoroidal material and cometary material, including volatiles, on the processing and modification of the surface [cf. 5].

In order to address many of MESSENGER's major objectives, direct compositional data must be determined from spacecraft instrument measurements. The problems plaguing ground-based spectroscopy and re-analyses of the Mariner 10 photometry of Mercury's surface terrain are also pertinent for MESSENGER's reflectance measurements: Mercury's close proximity to the Sun subjects its surface to alteration of the surface material, or "space weathering," unparalleled in magnitude in the Solar System. The compositional data already acquired foreshadow the possibility that space weathering limits compositional analyses of the spectral reflectance acquired by the Mercury Atmospheric and Surface Compositional Spectrometer (MASCS) and multispectral filters of the Mercury Dual Imaging System (MDIS). Fortunately, data acquired by the geochemical experiments, the X-Ray Spectrometer (XRS) and Gamma-Ray and Neutron Spectrometer (GRNS), will probe the surface elemental composition independent of the effects of space weathering. Color variations across Mercury's surface, correlated with surface geology, elucidate variations in composition and tie them to surface geological processes. To date, however, absorption features in reflectance data that could provide clues to specific surface mineralogy have not been identified.

Guided by laboratory reflectance spectra of terrestrial minerals and lunar rock and soil samples, we have begun a search for features in the ultraviolet (UV) and visible spectral region in the MDIS wide-angle camera (WAC) filter photometry and the MASCS spectroscopy acquired during MESSENGER's first two flybys and initial orbital observations. Here, we describe some plausible candidate minerals for Mercury's surface on the basis of presumptions derived from lunar and terrestrial geology. We recognize that this approach can be misleading; we are not ruling out other materials *a priori* as much as letting previous experience direct our search. We present two plausible sample absorption features that could be expected to be present on the basis of limited knowledge of Mercury's surface composition and space weathering effects in lunar samples.

2. Candidate Absorption Features

2.1 Ti and Ilmenite (TiO_2)

Tompkins and Pieters [7] have identified absorption features centered near 600 nm in laboratory reflectance spectra of lunar impact melts located near fresh craters on the Moon. In particular, spectra of the Apollo 17 black beads show this absorption feature, which is likely due to fine-grained ilmenite with olivine and glass. These workers generally attribute these absorption features to submicroscopic ilmenite inclusions in a transparent host material such as fine-grained plagioclase, and they note that the strength of this absorption feature depends more strongly on grain shape and size than on mineral abundance. Analyses of MESSENGER flyby data incorporating comparisons with the lunar surface suggest that Mercury's regolith contains a spectrally neutral opaque component [3,4]. Ilmenite has been proposed as a possible candidate [3], although XRS data suggest a low TiO_2 abundance [6]. We take one of the lunar sample spectra [7] and convolve it here with the MDIS filter transmissions to demonstrate how this absorption feature would appear in MDIS color measurements compared with the higher-resolution MASCS spectral measurements (Figure 1).

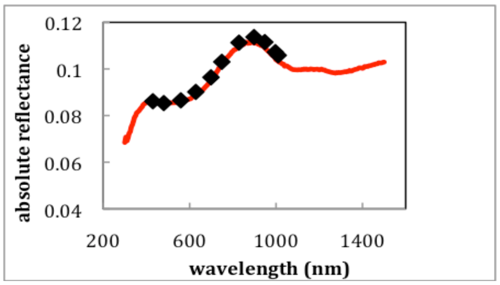

Figure 1: Absolute reflectance spectrum of lunar impact melt sample (particle size 45–75 µm) as measured (red line) [7] and convolved with MDIS WAC filter transmissions (black diamonds). The absorption feature near 600 nm is attributed to microcrystalline ilmenite [7].

2.2 High-calcium clinopyroxene

Clinopyroxenes with a calcium content ranging up to ~ 50% (spectral type-B clinopyroxenes) show an absorption feature attributed to an $Fe^{2+} \rightarrow Fe^{3+}$ charge-transfer transition centered near 700 nm [1,2], the presence and depth of which are not necessarily tied to the characteristics of the Fe^{2+} absorption feature centered near 1 µm [1,2]. No 1-µm feature has been identified in the MESSENGER MDIS or MASCS data to date, though it has been seen in a few spectra acquired telescopically [8]. This 700-nm feature, spectrally narrower than the microcrystalline ilmenite feature, spans the approximate wavelength range 570 to 830 nm, rendering it visible across five of the MDIS filters.

3. Conclusions

With a lack of obvious and expected absorption features in Mercury's spectral reflectance observed by MESSENGER spacecraft instrumentation, we are searching for more subtle absorption features that could be present in Mercury's spectrum and could indicate diagnostic information about Mercury's surface composition.

Acknowledgements

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References

[1] Cloutis, E.A., and Gaffey, M.J., *J. Geophys. Res*. **89**, 6329 (1991).

[2] Cloutis, E.A., and Gaffey, M.J., *Icarus* **102**, 203 (1993).

[3] Denevi, B.W., Robinson, M.S., Solomon, S.C., Murchie, S.L., Blewett, D.T., Domingue, D.L., McCoy, T.J., Ernst, C.M., Head, J.W., Watters, T.R., and Chabot, N.L., *Science* **324**, 613 (2009).

[4] Robinson, M.S., Murchie, S.L., Blewett, D.T., Domingue, D.L., Hawkins, S.E., III, Head, J.W., Holsclaw, G.M., McClintock, W.E., McCoy, T.J., McNutt, R.L., Jr., Prockter, L.M., Solomon, S.C., and Watters, T.R., *Science* **321**, 66 (2008).

[5] Solomon, S.C., et al., *Planet. Space Sci.* **49**, 1445 (2001).

[6] Starr, R.D., et al., this meeting (2011).

[7] Tompkins, S.C., and Pieters, C.M., *Meteorit. Planet. Sci*. **45**, 1152 (2010).

[8] Warell, J., Sprague, A.L., Emery, J.P., Kozlowski, R.W.H., and Long, A., *Icarus* **180**, 281 (2006).