

SURFACE MINERALOGY OF MAJOR GEOCHEMICAL TERRANES OF MERCURY: RESULTS FROM NIR (0.7-4.2 μm) GROUND BASED IRTF/SPEX SPECTROSCOPY.

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Introduction: MESSENGER data revealed that Mercury's surface is rich in Mg but poor in Al and Ca compared to terrestrial or lunar crustal materials [2] and is composed of various geochemical terrains with considerable differences in the mineral composition and abundances among different terrains [1, 3].

On October 20, 2018, ESA/JAXA's BepiColombo mission was successfully launched to Mercury. Part of its payload is the visible-infrared (V-NIR) spectrometer VIHI as part of the SIMBIO-SYS suite. VIHI covers the spectral region from 0.4 – 2 μm . In contrast, MESSENGER's Mercury Atmospheric and Surface Composition Spectrometer (MASCS), mapped Mercury only in the wavelength range from 0.4 to 1.45 μm [4]. Both these spectrometers do not cover the spectral regions longward of 2 μm as thermal emission from the hot surface of Mercury during daytime starts to contribute longward of $\sim 1.5 \mu\text{m}$. However, for Mercury the 0.7 – 4.2 μm spectral region encompasses characteristic spectral features such as (1) reflectance absorptions due to the Fe^{2+} electronic transfer in mafic silicates near 0.9 and 2.0 μm , and (2) volume scattering emission features longward of 2.8 μm , particularly important for understanding the iron-poor lithology of the planet [5]. Therefore, this study enables us to re-visit Mercury's geochemical terrains for its surface mineralogy beyond the 2 μm spectral region.

In this study, the global disk-resolved NIR spectroscopic data of Mercury was obtained at the Infrared Telescope Facility (IRTF) on Mauna Kea, HI, using the SpeX 0.7-5.3 μm Medium-Resolution Spectrograph and Imager on December 16-18, 2018. During this observation, Mercury was $\sim 63\text{-}70\%$ illuminated which covered the major geochemical terrains including high-Mg regions (HMR) where the largest abundances of Ca and S are found (HMR-CaS), northern plains (NP), and intermediate terrain (IT) [1] in the spectral region spanning 0.6 – 4.2 μm . These observations will not only yield new information of the surface mineralogy of Mercury for different geochemical terrains but will also help improve our preparations and planning for BepiColombo data acquisition and science for both spectroscopy and thermal inertia studies.

Telescope Facility: In this study, we obtained NIR spectra with almost complete longitude coverage of the surface of Mercury using SpeX, which is a 0.7 – 5.3 μm spectrograph on NASA's Infrared Telescope Facility (IRTF) on Mauna Kea, upgraded in 2014 (<http://irtfweb.ifa.hawaii.edu/~spex/>). Among the different spectral modes, in this study we used both the SXD mode, which covers the 0.7 – 2.55 μm range at a spectral resolution of $R \sim 2000$, and the LXD_short mode, covering the 1.67 – 4.2 μm spectral range at a spectral resolution of $R \sim 2500$. Both modes have a slit width and height of $0.3 \times 15''$.

Data Acquisition: Due to the small elongation angle of Mercury with respect to the sun, it is favorable to perform ground-based observations of Mercury during daytime. This is, however, not possible with many telescopes [6]. In this study, however, because of the unique daytime capabilities of the IRTF, we obtained observations in the evening on three consecutive days from 16-18 Dec 2018. At the time, Mercury was illuminated by $\sim 63\text{-}70\%$.

For each spectral mode, the spectrograph slit ($0.3 \times 15''$) was placed perpendicular to the central meridian near the poles, and after each spectral measurement the slit was moved systematically step-by-step across Mercury's disk from pole to pole to cover the entire surface, thereby producing global coverage for our NIR spectra. In order to remove the telluric absorption bands, standard stars having the same spectral type as the Sun analyzed simultaneously.

Calibration: To extract the reflectance spectrum in the range from 0.7-2.5 μm , the thermal excess radiation has to be removed. The surface temperature distribution of Mercury during the telescope observation is plotted in Fig. 1. The removal of the thermal emission is based on a fractal rough thermal model [7], which also addresses seeing. Further, an iterative scheme is employed that concurrently estimates the reflectance and the thermal excess radiation and thereby enables an adequate separation of both quantities. The iterative thermal correction scheme is adopted from [8] and the result is shown in Figure 2 (blue). The data are reduced using Spextool [9] for inherent and thermal corrections and the global spectral characterization of Mercury according to the geochemical terrain of the illuminated region.

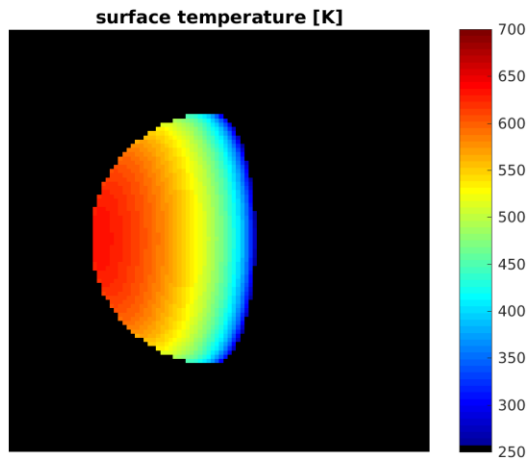


Figure 1. Simulated surface temperature distribution over the Mercury disk during the observation.

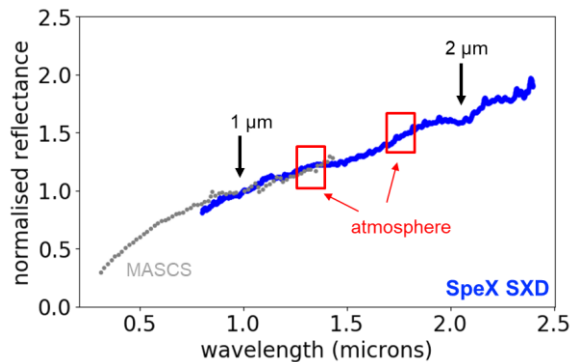


Figure 2. The calibrated SpeX spectra of northern plains (NP) geochemical terrane compared against the global average spectra of Mercury obtained using the NASA MESSENGER mission.

Preliminary results: Fig. 2 shows the reduced and thermally corrected spectra of the northern plains (NP) geochemical terranes of Mercury observed. Fig. 2 also compares the calibrated SpeX spectra with the global average spectra of Mercury obtained using the NASA MESSENGER mission. The calibrated SpeX spectra of NP terranes display minor 1 μm and 2 μm absorption bands suggesting the presence of Ca-rich pyroxenes as suggested by previous work [10]. The SpeX-derived mineralogy beyond 2 μm for these geochemical terranes will help to carefully choose the corresponding Mercury analogues to be studied over a wide spectral range under Mercury's extreme daytime temperature conditions [11]. Such a specialized spectral library will allow for a spectral characterization of previous (MESSENGER) and future datasets (BepiColombo).

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