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The Northwest Africa 7325 meteorite – a potential spectral analog for Mercury?

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Abstract

We have completed spectral measurements of a 5 g sample of the Northwest Africa 7325 meteorite. On the basis of its mineralogical and chemical characteristics (e.g., the high Mg/(Mg+Fe) ratio) it has been speculated that this meteorite might have originated from Mercury. At the Planetary Emissivity Laboratory (PEL) in Berlin we have obtained spectra of different grain size fractions of the meteorite in the visible, near-, and thermal-infrared wavelength range. Because the meteorite has a very low ferrous iron content of only 1.57 wt%, it might be a good spectral analog for Mercury. For this reason we have compared the visible spectra with average spectra for two global regions of Mercury obtained by the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) instrument on NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft. First inspection shows some similarities between the spectral slope of the NWA 7325 meteorite and average Mercury spectrum. However, the meteorite has a much stronger spectral contrast than the average Mercury spectrum. Although the NWA 7325 spectrum is one of the best-fitting analog spectra encountered to date, it is not a perfect match to the spectrum of Mercury. This comparison highlights yet again how featureless Mercury's surface spectra are at visible and near-infrared wavelengths.

1. Introduction

Northwest Africa 7325 is a 345-g greenish-hued meteorite that was found in the Sahara in February 2012 and studied by Irving et al. [1]. These authors found mineralogical and chemical characteristics that are partly consistent in composition with Mercury surface material [2], although this similarity warrants further investigation [3]. Irving et al. [1] classified the meteorite as a "reduced, iron-poor cumulate olivine gabbro from a differentiated parent body".

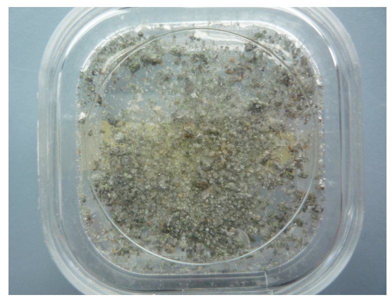

Figure 1. Unsieved fraction of NWA 7325

2. Visible and infrared spectra

We handled the meteorite sample following our standard procedures. We crushed a 1-g bulk sample of the meteorite into smaller particles, and then we sieved them into the four ranges of particle sizes typically used for spectral reflectance measurements at PEL. In addition we used an unsieved fraction (Figure 1) that remained from crushing the bulk sample. The average grain size of the unsieved fraction was approximately 250 μm.

For this study we used our purged Bruker IFS 88 Fourier Transform Spectrometer with a Harrick Seagull™ variable-angle reflection accessory to measure the biconical reflectance. The visible and near-infrared (0.45–1.1 μm) reflectance spectra (Figure 2) for all the samples are obtained with a Si-diode detector and a quartz beam splitter. The mid-infrared (1.5-16 μm) spectra (Figure 3) are obtained with a nitrogen-cooled MCT detector and a KBr beam splitter. We chose illumination and emission angles $i = e = 40°$ that are comparable to the majority of the observations from the MASCS instrument.

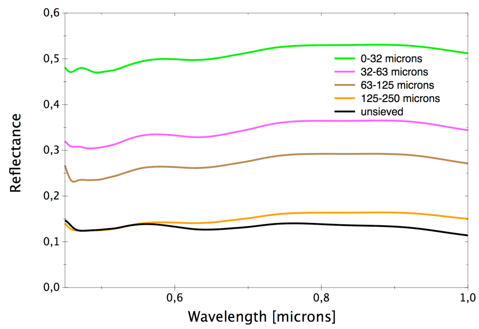

Figure 2. Visible reflectance spectra of 4 grain size fractions and the unsieved fraction of NWA 7325

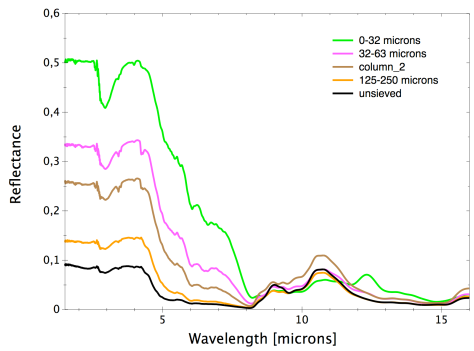

Figure 3. Infrared reflectance spectra of 4 grain size fractions and the unsieved fraction of NWA 7325

4. Comparison with MASCS data

The MASCS instrument on the NASA MESSENGER mission is currently obtaining spectra of Mercury at ultraviolet, visible, and near-infrared wavelengths [4]. It has revealed so far a surface characterized by a red-sloped but nearly featureless average spectrum. A recent global analysis using a clustering approach [5] has revealed two spectral surface units.

A comparison of the spectrum of the unsieved fraction of the meteorite with the average spectrum of Mercury as well as the average spectra of the two spectral units id is shown in Figure 4. All spectra are normalized at 700 nm to match absolute brightness. We focused the comparison on the spectral range used for the global clustering analysis.

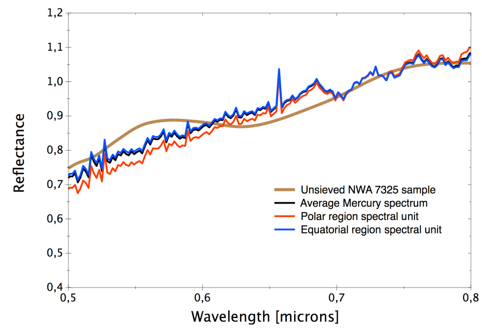

Figure 4. Spectra of the unsieved fraction of NWA7325 compared with an average Mercury spectrum and the average spectra for the polar and equatorial region as defined by cluster analysis [5]

6. Summary and Conclusions

At visible wavelengths NWA 7325 shows very little spectral contrast (see also [6]). A comparison with the MESSENGER MASCS data is so far inconclusive. The visible spectra of the meteorite show a spectral slope compatible with average Mercury spectra. The lack of spectral contrast in the Mercury spectra compared with the unaltered meteorite spectra might be caused by high temperature thermal processing. Laboratory work indicates that some materials lose substantial spectral contrast when exposed to Mercury surface temperatures [7]. So far we have obtained spectral measurements only on fresh meteorite samples. We are planning to perform alteration experiments on a small subset of the meteorite sample to study especially the effect of peak surface temperatures on the spectral signatures.

References

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