OPTIMIZATION OF NARROWBAND VISIBLE TO NEAR-IR FILTERS FOR THE PSYCHE MULTISPECTRAL IMAGER S. D. Dibb[1] and J. F. Bell III[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ (sdibb@asu.edu).

Introduction: The asteroid (16) Psyche is the largest of the M-type asteroids (diameter > 200 km) and is the target of the Psyche Discovery-class mission to be launched in the summer of 2022 [1]. Formation hypotheses for (16) Psyche range from condensation of highly-reduced metal-rich primordial material to exposure of a metallic core after planetary differentiation and subsequent stripping of a silicate mantle [2]. The Psyche Multispectral Imager is a visible to short-wave near-infrared (~400 to ~1100 nm) CCD camera designed to characterize topography, geology, and (to a limited extent) composition of the surface of (16) Psyche [3]. The Imager consists of a pair of identical (for redundancy) 148 mm focal length *f*/1.8 camera assemblies and accompanying digital electronics assemblies [3]. Internal to the camera assemblies are filter wheels that include 8 filters specifically chosen to maximize the Imager's ability to address Psyche mission science objectives (Table 1), including the ability to characterize the degree of mixing of silicate material and metal on the surface, as well as to detect the presence of sulfide minerals like oldhamite and troilite that are indicative of potentially reducing conditions during (16) Psyche's formation. The Psyche mission will be the first close-up encounter with a metallic object, and thus the wavelength centers of the Imager's filters must be carefully chosen to best capture reflectance features in the spectrum of (16) Psyche that can address mission science objectives.

Table 1. Currently proposed Imager filters

Band[1]	*λ (nm)*	*Purpose*
Clear	540±280	unfiltered for OpNav, topography, and geologic characterization
B	437±50	sulfide continuum, blue component of true color
o	495±25	search for evidence of sulfides
v	550±25	sulfide continuum, green component of true color
w	700±50	peak reflectance continuum, red component of true color
0.75	750±25	search for low-Ca pyroxene
p	948±50	search for high-Ca pyroxene, characterize weak Earth-based feature
z	1041±90	search for evidence of olivine

[1]Eight Color Asteroid Survey designation [4]

In this work, we present reflectance spectra of 14 meteorites belonging to a range of classes which represent possible analogs to the surface composition of (16) Psyche (Table 2). These spectra are convolved to potential Imager filter bandpasses to help optimize the filters for examination of Psyche-relevant materials.

Method: The Center for Meteorite Studies (CMS) at Arizona State University offers one of the best public collections of meteorites in the world. We have selected a set of meteorite samples from the CMS collection that contain a broad range of materials relevant to potential Psyche surface compositions to address mission science objectives (Table 2). The meteorites span a range of classes, including type IAB and IVA irons, a mesosiderite, a group of H and L ordinary chondrites, a lodranite, aubrite, enstatite chondrite, diogenite, and pallasite. A brief justification for why each sample was chosen is shown in Table 2. Some of the samples were analyzed as powders, gravels, or roughened/polished surfaces when available, to examine the effect of grain size and surface roughness on filter selection.

We used an Analytical Spectral Devices FieldSpec 3 (FS3) spectrophotometer to capture bidirectional reflectance spectra from 350-2500 nm to cover the proposed Imager filter range of visible to near-infrared reflectance. Our light source is a quartz-tungsten lamp and all spectra are calibrated to a Spectralon white reference standard, which has near-uniform reflectance in the FS3 measurement range. The incidence angle of the lamp was 30° and the emission angle was 0°, perpendicular to the sample stage. The wavelength range measured by the FS3 enables measurement of absorption features near 1000 nm that are attributable to ferrous iron in silicates like olivine and pyroxene [5]. The center of this absorption band changes with varying cation composition, and so the center of this band can be used to study the type of silicate in the meteorite [5]. Furthermore, the spectral range of the Imager is intended to capture weak absorption features from some sulfide minerals, such as oldhamite at 495 nm and 948 nm, and possibly a change in slope of the troilite reflectance spectrum at ~650 nm [6].

Results: Several normalized reflectance spectra of the meteorites used in this study are shown in Figure 1. These include the spectrum of Canyon Diablo, Shalka, and St. Michel. The initially-proposed Imager filter bandpasses are shown as colored bands on Figure 1. The spectrum of Canyon Diablo is featureless and red-sloped, which is expected for iron meteorites and is similar to the spectra of M-type asteroids [7]. The spectrum of Shalka, a diogenite that is almost entirely pyroxene, shows a prominent absorption feature centered near 920 nm. Finally, the reflectance spectrum of St. Michel is indicative of a broad olivine absorption feature centered near 1050 nm. Overall, the absorption features exhibited by silicates are well-captured by the currently proposed Imager filters, and absorption features around 1000 nm for relevant pyroxene- and olivine-bearing samples are easily distinguishable in the convolved data.

Future work before final filter selection includes analysis of the filter performance with a wider variety of sulfide minerals, detailed study of the effects of grain size and surface roughness, possible examination of the effects of irradiation to simulate space weathering, and convolution of as-built filter profiles with the meteorite spectra.

References: [1] Elkins-Tanton *et al.* (2014), *LPSC XLV*, Abstract #1253. [2] Elkins-Tanton *et al.* (2016), *LPSC XLVI*, Abstract #1631. [3] Bell *et al.* (2016), *LPSC XLVII*, Abstract #1366. [4] B. Zellner *et al.* (1985), *Icarus*, 61, 355. [5] Cloutis *et al.* (1990), *JGR*, *95*, 8323. [6] Burbine *et al.* (2002), *Meteoritics & Planet. Sci.*, *37*, 1233. [7] Pieters and McFadden (1994), *Annu. Rev. Earth Planet. Sci.*, *22*, 457.

Table 2. Meteorite samples used so far in this study

Name	Class	Justification
Canyon Diablo	IAB iron	Type IAB iron with high metal content and sulfide and other inclusions
Odessa (iron)	IAB iron	Type IAB iron with high metal content and some silicate inclusions
NWA 8234	Mesosiderite	Intermediate bulk metal content with olivine and low-Ca pyroxene
Abee	EH4	Enstatite mineralogy, inclusions of oldhamite in breccia matrix
St. Michel	L6	Low metal content, diverse silicate composition
Lodran	Lodranite	Intermediate metal content, inclusions of olivine and orthopyroxene
Mbale	L5/6	Low metal content, diverse silicate composition
Creston	L6	Low metal content, diverse silicate composition
Allegan	H5	Intermediate-low metal content
Shalka	Diogenite	HEDs represent differentiated body, abundant pyroxene
Norton County	Aubrite	Silicate mineralogy indicative of reducing conditions
Steinbach	IVA iron	High metal content with large pyroxene inclusions
Esquel	Pallasite	High metal content with large olivine inclusions
Odessa (silicated)	IAB iron	Similar chemistry to Odessa, unique history inferred from textural evidence

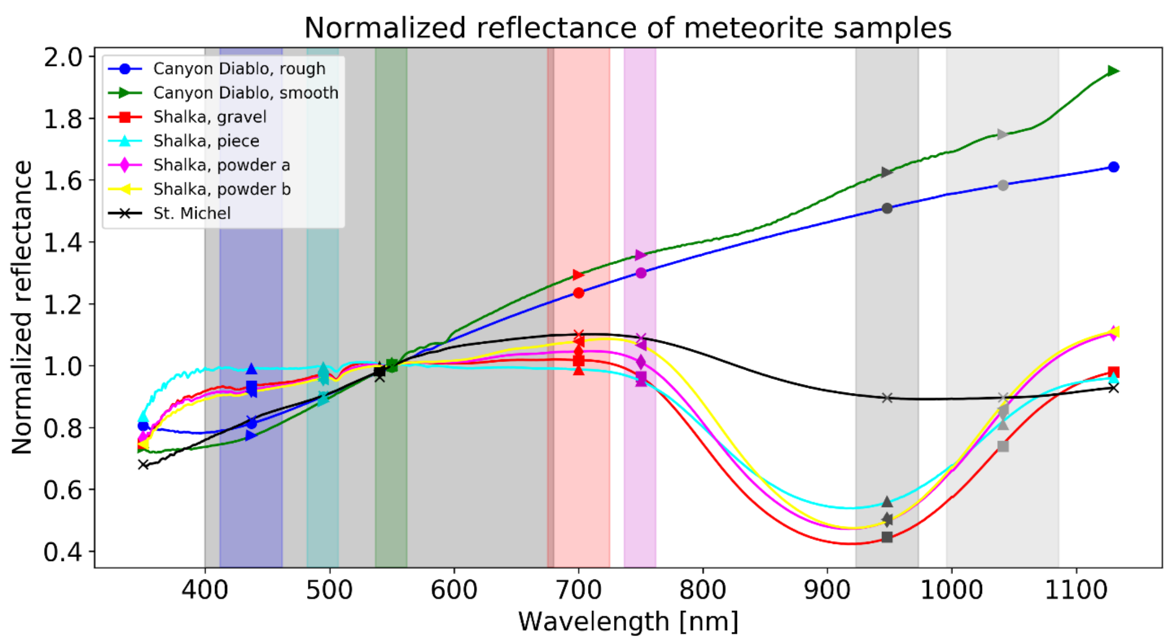

Figure 1. Reflectance spectra of some samples in this study, normalized to 1.0 at 550 nm. Imager filter bandpasses are shown as colored/shaded vertical bars and convolved filter values are shown as colored symbols.