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2 Pallas and 10 Hygiea in the 3-µm spectral region

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Abstract

The asteroids 2 Pallas and 10 Hygiea are large C-complex objects with hydrated minerals. Their mineralogies differ from one another, with Pallas more akin to the CM meteorites and Hygiea showing a similar spectrum to Ceres. We will present compositional models for Pallas and Hygiea and a rudimentary map of band depths across Pallas' surface.

1. Background

With the imminent arrival of the Dawn spacecraft at 4 Vesta and its subsequent departure for 1 Ceres, much attention has been directed at these two objects, with great progress made in advance of Dawn's encounters. However, rather less is known of the other two members of the "big four": 2 Pallas and 10 Hygiea.

Pallas is the second-largest asteroid (545 km diameter), larger but less massive than Vesta. It has by far the largest inclination of any large asteroid (over 34°), and is a member of the B spectral class [1]. Recent HST observations show evidence of a facet or crater exhibiting a different UV-visible color than other parts of Pallas' surface [2].

Hygiea is the fourth-largest asteroid (~420 km diameter), the largest object between Pallas and the Jovian system by a sizeable margin. Hygiea has a very long rotation period (27.6 hours) and a relatively elongated shape. It is a C-class asteroid, like Ceres [1].

The spectral class memberships for Pallas and Hygiea associate them with the carbonaceous chondrites. However, neither one shows strong absorptions in the 0.5-2.5 µm region, hampering compositional analyses. Here, we take advantage of the 3-µm spectral region, where both Pallas and Hygiea show absorptions due to water/OH in minerals [3,4], to investigate meteorite affinities and mineralogies for Pallas and Hygiea.

2. Observations and Discussion

The observations presented were taken as part of the L-band Main-belt and NEO Observing Program (LMNOP), using the SpeX instrument at the NASA IRTF in long-wavelength cross-dispersed ("LXD") mode. This mode allows simultaneous observation of both sides of the atmospheric "water gap": the spectral region from ~2.5-2.85 µm where telluric absorptions reduce transmission to near zero. The data were reduced using Spextool and additional IDL routines, as in previous recent work [5].

UT Date	Sol Dist (AU)	Earth Dist (AU)	Phase Angle (°)	Object
8/23/02	3.47	3.18	17	Hygiea
3/2/05	2.32	1.39	11	Pallas
5/18/05	2.83	2.16	18	Hygiea
9/8/06	2.95	2.31	17	Hygiea
9/8/06	3.37	3.00	17	Pallas
9/17/06	2.96	2.45	19	Hygiea
6/12/07	3.34	3.15	18	Pallas
9/12-13/07	3.23	2.26	5	Pallas
9/12-13/07	3.35	2.41	8	Hygiea

Table 1: Observational circumstances

2.1 Pallas

Pallas has been observed by the LMNOP on five dates from 2002-2007. The 3-µm band shape for Pallas is reminiscent of CM chondrites, as has been noted by earlier workers [4,6]. Pallas' 3-µm band shape is very common among C-complex asteroids, and a full understanding of Pallas' mineralogy will be applicable to the entire group of "Pallas-type" asteroids [7]. Recent work [8,9] demonstrated that meteorite spectra available in data libraries can be affected by telluric water, artificially increasing the band depth and width in the 3-µm region. We will model spectra of Pallas using recent laboratory data taken to minimize this problem in order to better understand the connection between it and the CM meteorites and understand its water abundance.

Three of the observing dates for Pallas are close in time to the AO observations of Carry et al. (2009) [10] in addition to multiple observations the week of the HST observations presented by Schmidt et al. (2009) [2]. These close timings help tie the spectra more closely to the imaging observations and lower uncertainties in the sub-observing points for the spectra. Figure 1 shows a preliminary schematic map of Pallas' 3-µm band depths, with larger squares representing deeper band depths. Also placed on Figure 1 is a circle representing the rough position of a facet, or crater, seen in the HST data. While more work is needed, there appears to be a hint that band depths may vary with distance to this facet/crater. Future work will include compositional mapping of Pallas through a combination of spectral and color data and a rough shape model of Pallas.

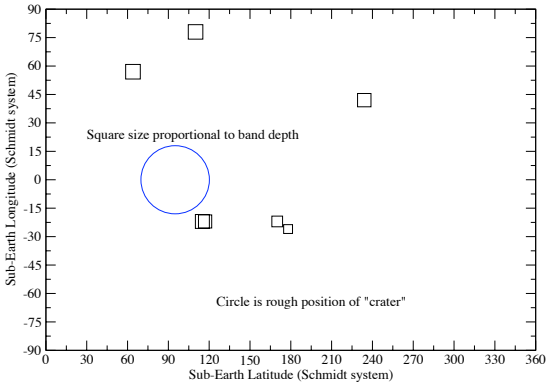

Figure 1: This rough map shows the band depths of the 3-µm band on Pallas, with the position of the square placed on the sub-Earth point at the time of observation and deeper bands represented by larger squares. Also on the map is a circle representing the position of a potential crater found in HST images of Pallas (Schmidt et al. 2009).

2.2 Hygiea

Hygiea has been observed on six dates, shown in Table 1. Spectra of Hygiea show hints of variation in the 3-µm region, but relatively low S/N for some spectra and Hygiea's uncertain pole position leaves us unable to conclude whether this variation is real at this time.

We can conclude, however, that the best quality spectra of Hygiea are very similar to the spectrum of Ceres, seen in Figure 2 [11,12]. Carbonates and brucite have been detected on Ceres' surface, minerals that are consistent with heavy alteration of olivine [13]. Physical studies and modelling of Ceres suggests a thick ice shell exists in its interior [14,15]. Its spectral similarity to Ceres opens the possibility that it may have had a similar history and a similar structure.

We will present an analysis of Hygiea's spectrum to compare and contrast it to Ceres' mineralogy.

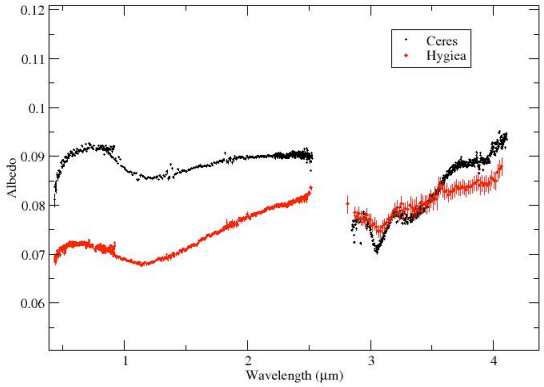

Figure 2: There is great similarity between the spectra of Ceres (black) and Hygiea (red) throughout the visible-NIR region, suggesting that they have at least qualitatively similar mineralogies.

References: [1] Bus, S. J. and Binzel, R. P. *Icarus* vol. 158, pp. 146-177, 2002. [2] Schmidt, B. E. et al. *Science* vol. 326, pp. 275-277, 2009. [3] Jones, T. D. et al. *Icarus* vol. 88, pp. 172-192, 1990. [4] Rivkin A. S. et al. *Asteroids III* 2002. [5] Volquardsen E. L. et al. *Icarus* vol. 187, pp. 464-468 2007. [6] Hiroi, T. et al. *Met. Plan. Sci.* vol. 31, pp. 321-327, 1996. [7] Rivkin, A. S. *DPS 39,* Abst. #33.03, 2007. [8] Beck, P. et al. *Geochem. Cosmochem. Acta* vol. 408, pp. 4881-4892. [9] Takir, D. et al. *DPS 43*, 2011. [10] Carry B. et al. *Icarus,* vol. 205, pp. 460-472, 2010. [11] Rivkin et al. *Space Sci. Rev.* in press. [12] Takir, D. and Emery, J. P. *DPS 42,* Abst. #53.09, 2010. [13] Milliken R. E. and Rivkin A. S. (2009) *Nature Geosc.* vol. 2, 258-261. [14] Thomas, P. C. et al. *Nature*, vol. 437, 224-226, 2005. [15] Castillo-Rogez, J. C. and McCord, T. B. *Icarus*, vol. 205, pp. 443-459, 2010.