Surface Mineralogy of Mars-Crossing Asteroid 1747 Wright: Analogous to the H Chondrites M. P. Lucas[1] and J. P. Emery[1], [1]Department of Earth and Planetary Sciences, University of Tennessee, 1412 Circle Drive, Knoxville, TN 37996, mlucas9@utk.edu

Introduction: Asteroid dynamical work has suggested that differentiated asteroids, precursors of metallic (core) and olivine-rich (mantle) fragments may have formed in the terrestrial planet region and are now interlopers to the inner main-belt [1]. Furthermore, recent work has suggested that the Hungaria asteroids are the survivors of an extended and now largely extinct portion of the asteroid belt that existed between 1.7 and 2.1 AU early in solar system history [2]. The mineralogy of these relatively close objects hold important clues to the dynamical evolution of the inner-Solar System. In particular, a key aspect of asteroid mineralogy is the abundance and composition of olivine and pyroxene, which can reveal details regarding the degree (or lack) of igneous differentiation.

Pure olivine-rich A-types remain cryptic among the observable asteroids. However, a number of small (<~8 km) asteroids that reside *interior* to the main-belt (i.e., Hungaria Group, Mars-crossers, near-Earth asteroids) are thought to be rare olivine-rich A-type asteroids in one or more visible-light taxonomic surveys [3,4,5,6]. Therefore, it is vital to examine these objects not just in terms of their taxonomic types, but also in terms of their detailed mineralogy. Interestingly, eight presumed A-types *interior* to the main-belt have recently been shown to be more interrelated with S-type asteroids after further spectral data was acquired into the near-infrared (NIR) [7,8]. These results are consistent with spectral studies [9,10] that indicate that two-thirds of all near-Earth asteroids (NEAs) belong to the S- or Q-complexes. These taxonomic types are spectrally analogous to ordinary chondrites [10].

Here we present the visible and near-infrared spectrum (VISNIR) of the Mars-crossing (MC) asteroid 1747 Wright (a = 1.709 AU), heretofore only recorded in visible wavelengths. The spectral type of this asteroid has been uncertain as taxonomic surveys have identified 1747 Wright as an A-type [3,6], Sl-type [5], or an Ld-type [6]. We hypothesize that 1747 Wright is relatively olivine-rich. We test this hypothesis by performing a detailed spectral band parameter analysis.

Observations: We observed the asteroid on 2012 September 18 using the SpeX spectrograph [11] on the NASA Infrared Telescope Facility (IRTF) in low-resolution prism mode to obtain a NIR spectrum. We performed the observations remotely from the University of Tennessee Knoxville (UTK). The asteroid was selected for observation as part of a larger study [8] to confirm the actual mineral abundances and compositions of asteroids presumed to be A-type from visible light spectral surveys. Data reduction was performed with IDL-based Spextool provided by the IRTF.

Spectral Band Parameter Measurements: Band parameter values, which include Band I and Band II centers and depths, and Band Area Ratio (BAR) were measured after dividing the absorption bands by a straight-line continuum. Band centers and depths were measured 10 times using different order polynomial fits (typically 2nd through 5th order) and different ranges of values within each absorption band (e.g.- full band, lower 1/2 band, lower 1/3 band) to derive the associated uncertainties involved with each band parameter. Averages of these measurements are adopted as the final values (Table 1). To compare these values to those measured at room temperature in the laboratory we applied temperature corrections (Δ) as described in [12] after calculating the average surface temperature of the asteroid based on the method found in [13].

Results: NIR spectra of asteroids are utilized to determine the mineralogy of their surfaces from the strong 1 µm and/or 2 µm absorption bands caused by the presence of the Fe^{2+} cation in the mafic silicate minerals olivine and pyroxene. Mineral abundances and compositions of asteroid surfaces can effectively be extracted by comparing the band parameters of asteroid spectra to laboratory-based calibrations derived from meteorite analogues.

VISNIR Spectrum of 1747 Wright: An average of eight 120 s SpeX integrations yielded the spectrum shown in Figure 1. The visible portion of the spectrum is from the SMASS II survey [5]. All reflectance values were normalized to unity at 0.55 µm. The presence of Band I near 0.9 µm and Band II near 1.9 µm strongly indicates the presence of pyroxene.

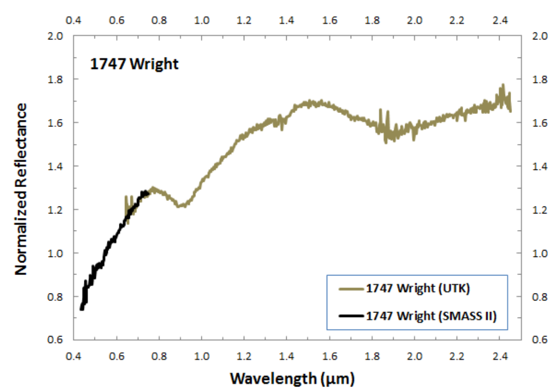

Figure 1. – VNIR spectrum of 1747 Wright obtained with the SpeX instrument on the NASA IRTF in low-resolution prism mode.

Table 1. – Measured spectral band parameters with uncertainties for Mars-crossing asteroid 1747 Wright.

Parameter	Band Center (µm)	ΔBand Center (µm)	Band Depth (%)	ΔBand Depth (%)	BAR	ΔBAR
Band I	0.924 ±0.007	--	11.11 ±1.10	--	--	--
Band II	1.914 ±0.014	1.933 ±0.014	7.13 ±1.07	5.70 ±1.07	1.16 ±0.21	1.08 ±0.21

Δ – temperature corrected values, calculated equilibrium surface temperature of 1747 Wright = 204 K.

Asteroid Taxonomy: We identified the taxonomic class of 1747 Wright as Sw (Table 2) using the BusDeMeoClass asteroid spectrum classification tool (http://smass.mit.edu/busdemeoclass.html).

Mineral Abundance and Composition: We derived mafic silicate mineral abundances and compositions (Table 2) using the calibrations of [14]. Those authors used a suite of 48 ordinary (H, L, and LL) chondrites containing orthopyroxene (Opx), clinopyroxene (Cpx), and olivine (Ol) to establish correlations between S-type asteroid spectra and mineralogy. Using these calibrations, 1747 Wright has an ol/(ol+px) ratio of 0.47 ±0.05, and mafic silicate compositions of olivine Fa_{13-17} (fayalite; Fe_2SiO_4) and pyroxene $Fs_{12.6-15.4}$ (ferrosilite; $FeSiO_3$). Figure 2 shows 1747 Wright plotted on a Band I center vs. Band II center plot [15], indicating that the pyroxene content of this asteroid corresponds to a low-calcium content orthopyroxene composition. Figure 3 shows 1747 Wright indicated on an S-asteroid subtype plot of [16]. Uncertainties in BAR place the asteroid in either the SIV "boot" analogous to ordinary chondrite material, or in the SVI field where Opx>Ol, which is consistent with the derived ol/(ol+px) ratio and with the orthopyroxene composition from Figure 2.

Mineral abundances and compositions derived from measurements of spectral band parameters indicate an ordinary chondrite-like mineralogy for 1747 Wright, not an olivine-rich A-type [15,16]. Based on the mineralogies of 47 NEAs, the most probable ordinary chondrite meteorite analogue for 1747 Wright is the H chondrites (see Fig. 2 in [10]). H chondrite mineralogies are most likely derived from a 3:1 resonance source region [17] or the ν_6 secular resonance [10]. However, 1747 Wright is an H chondrite example from a lower-probability [10,17] MC source region.

Table 2. – Mineralogy and taxonomy of 1747 Wright.

Asteroid	ol/(ol+px)	Δol/(ol+px)	Fo	Fa	Fs	Taxonomy Bus-DeMeo	Gaffey S-subtype
1747Wright	0.45 ±0.05	0.47 ±0.05	85 ±2	15 ±2	14 ±1.4	Sw	SIV or SVI

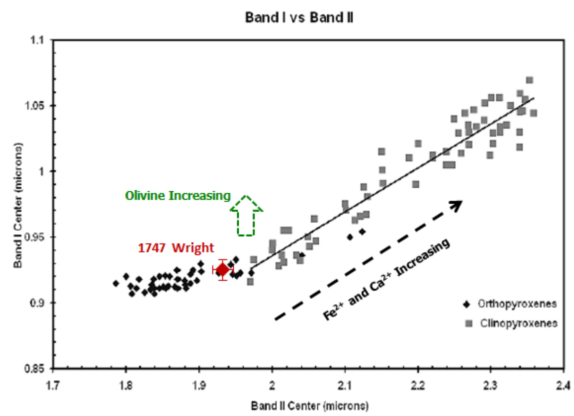

Figure 2. – Band-band plot showing the Opx-Cpx mixing line from [15]. 1747 Wright plots within the field of orthopyroxene.

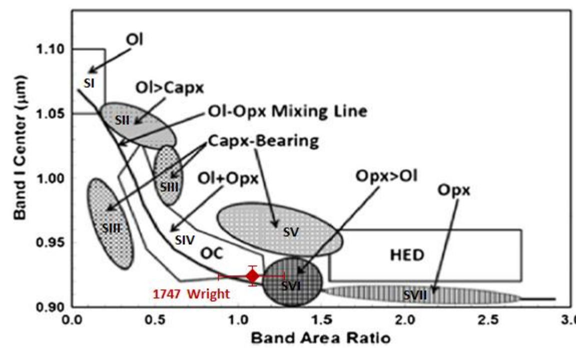

Figure 3. – Asteroid S-subtypes plot from [16]. 1747 Wright plots within the SIV or the SVI field. Ol-Opx mixing line is indicated.

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