REFLECTANCE SPECTROSCOPY OF ALMAHATA SITTA METEORITE SAMPLES FROM ASTEROID 2008 TC3. T. Hiroi[1], Peter Jenniskens[2], Janice L. Bishop[2], and Tahani Shatir[3], [1]Department of Geological Sciences, Brown University, Providence, RI 02912, USA (takahiro_hiroi@brown.edu), [2]SETI Institute, Carl Sagan Center, 515 North Whisman Road, Mountain View, CA 94043, USA, [3]University of Khartoum, P. O. Box 321-19, Khartoum 11115, Sudan.

Introduction: Almahata Sitta meteorite stones are the first observed fall from a tracked and spectrally observed asteroid, 2008 TC_3 [1]. This enabled a rare opportunity to compare an asteroid reflectance spectrum with that of a meteorite derived from it. As a preliminary study, the visible-NIR reflectance spectra of chip and powder samples of select stones of Almataha Sitta meteorite have been measured to provide insights into the surface and internal compositions and possibly the surface physical properties of 2008 TC_3. In addition, Fourier transform infrared (FT-IR) reflectance spectra of the samples have been measured to investigate the degrees of terrestrial weathering and any trend of compositional change among the samples.

Experimental: Small (1-2 cm) chip samples of 11 stones #4, #7, #19, #25, #27, #32, #36, #44, #47, #50, and #51 of the Almahata Sitta meteorite and Ochansk H4 chondrite were placed individually in a black Teflon dish embedded with aluminum foil and oriented so that the freshest and flattest face is up. A portion of each of 7 stone (#4, #19, #32, #36, #44, #50, and #51) chips were ground and dry-sieved into coarse (125-500 μm) and fine (<125 μm) powder samples. Each powder sample was measured in the Teflon dishes.

Bidirectional visible-NIR reflectance spectra of the samples were measured using the RELAB Spectrometer [2] over the wavelength range from 320 to 2550 nm at 10 nm intervals. All the chip and powder samples were measured at the standard viewing geometry of 30 degree incidence (*i*) and 0 degree emergence (*e*) angles. In addition, 5 chip samples of stones #4, #7, #25, #27, and #47 were also measured at i = 19 degree and e = 0 degree to match the Sun-asteroid-Earth phase angle 18.6 degrees for a spectral observation of the asteroid 2008 TC_3 [1]. Each sample was spun to average heterogeneity over the azimuth angle.

Off-axis biconical FT-IR reflectance spectra of all the samples were measured over the wavelength range from 7000 to 400 cm^{-1} (about 1.4 to 25 μm in wavelength) with 4 cm^{-1} resolution.

Results: Bidirectional visible-NIR reflectance spectra of chip samples of stones #4, #7, #25, #27, and #47 of Almahata Sitta meteorite at two viewing geometries are shown in Fig. 1. The spectral differences between the two measurement geometries are limited to a slight increase in brightness and change in continuum slope. All the major absorption bands near 1 and 2 μm were retained. The stone #4 chip spectrum exhibits the weakest absorption features, while the #25, #27, and #47 chip spectra contain pyroxene bands near 1 and 2 μm, and the #7 chip spectrum shows a significant olivine component through a relatively strong ~1.25 μm shoulder band and a weak ~2 μm band.

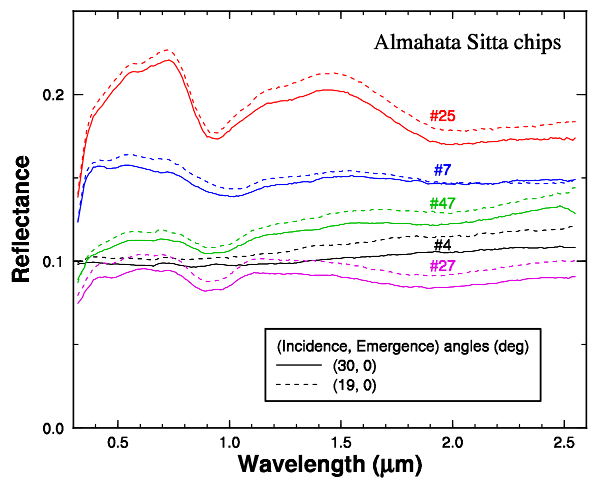

Fig. 1. Bidirectional visible-NIR reflectance spectra of Almahata Sitta meteorite chips.

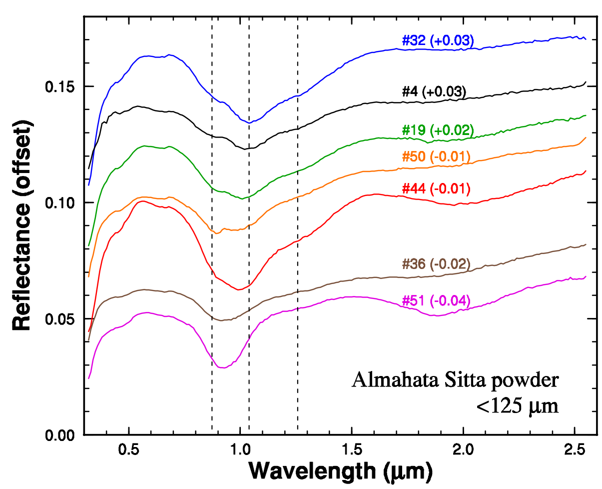

Fig. 2. Visible-NIR reflectance spectra of fine powder samples of Almahata Sitta. Reflectance values are offset by the amounts in parentheses for clarify. Three vertical broken lines indicate approximate olivine absorption band positions.

Shown in Fig. 2 are the bidirectional visible-NIR spectra of fine powder samples of select Almahata Sitta meteorite stones. These spectra are plotted with offsets in the order of apparent mineral assemblage: olivine-rich at the top, and pyroxene-rich at the bottom. These powder sample spectra indicate more diversity in lithology than those of the chip samples in Fig. 1. The spectrum of the stone #51 powder sample in Fig. 2 shows relatively narrow absorption bands at ~0.5 and 1.9 µm, which may indicate terrestrial weathering.

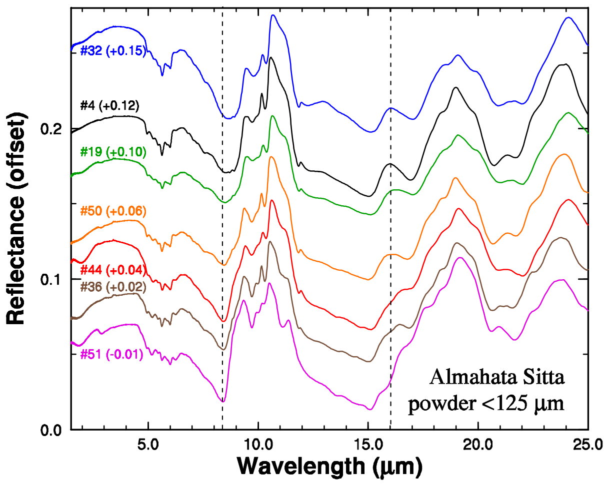

Fig. 3. Off-axis biconical FT-IR reflectance spectra of fine power samples of Almahata Sitta meteorite particulates. Reflectance values are offset for clarify by the amounts indicated. Two vertical broken lines mark the Christiansen feature and a forsteritic olivine feature near 16 µm.

Shown in Fig. 3 are the FT-IR spectra of fine powder samples that are color-coded and offset in the same order as in Fig. 2. Two vertical broken lines indicate the Christensen feature and a small band characteristic of forsteritic olivine that show systematic variations. The #51 sample shows the strongest 3 µm hydroxyl band. In combination with the presence of the 0.5 and 1.9 µm bands in Fig. 2 as mentioned earlier, it strongly suggests that stone #51 is terrestrially weathered.

Discussion: The visible-NIR spectrum of the #25 chip is very similar to that of an H chondrite (Fig. 4). Among all the chip and powder samples of Almahata Sitta meteorite stones, the stone #4 samples exhibited the similar flat spectra in the visible range and a shallow 1 µm band, most similar to the asteroid 2008 TC_3 spectrum [1]. Shown in Fig. 5 are attempts to mimic the asteroid spectrum using only stone #4 spectra and weighted average of all the chip samples except the #25 stone. Both average spectra can reasonably reproduce the asteroid spectrum in the visible and 1-µm regions but differ in the NIR region. Identifying an asteroid made of materials similar to Almahata Sitta meteorite is complex because its spectral shape would highly depend on which lithologies in Fig. 1 and 3 exist on the surface.

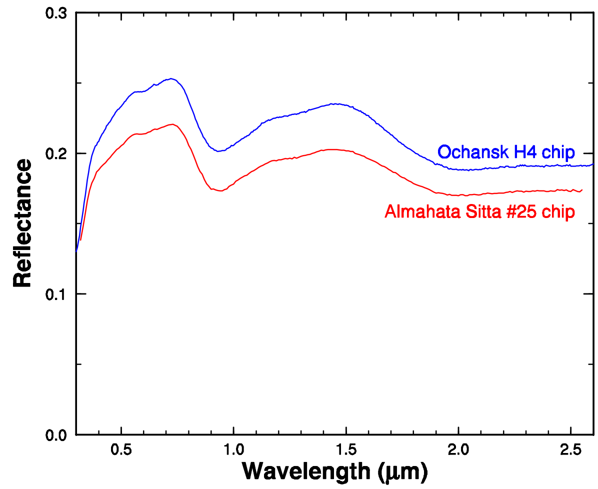

Fig. 4. Comparison of the visible-NIR reflectance spectra of an Almahata Sitta #25 stone chip and an H4 chondrite chip.

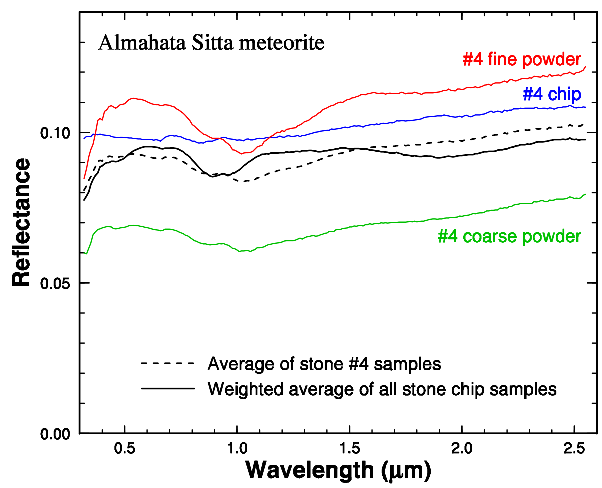

Fig. 5. Comparison of visible-NIR reflectance spectra of stone #4 samples of Almahata Sitta meteorite, their average spectrum, and the weighted average spectrum of all stone chips except stone #25 (probably an H chondrite).

References: [1] Jenniskens P. et al. (2009) *Nature 458*, 485. [2] Pieters C. M. and Hiroi T. (2004) *LPS*, *XXXV*, Abstract #1720.

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