CHARACTERIZATION OF ABSORPTION BANDS (0.6-0.9 \mu m) IN REFLECTANCE SPECTRA OF PRIMITIVE ASTEROIDS: T. Hiroi, Dept. of Geological Sciences, Brown University, Providence, RI 02912; F. Vilas, SN3, NASA Johnson Space Center, Houston, TX 77058

High-resolution reflectance spectra (0.5-0.95 \mu m) of ten selected primitive asteroids (C, G, F, and P classes) have been deconvolved and shown to have the 0.6, 0.7, and 0.9-\mu m absorption bands with consistent band centers and widths. The CM2 meteorites which show aqueous alteration, have been shown to have similar bands and sometimes an additional 0.8-\mu m band. Septechlorites (serpentines + chlorites), typical products of aqueous alteration in CM2 meteorites, also have the 0.7 and 0.9-\mu m bands but no 0.6-\mu m band. The 0.6-\mu m band is probably due to some other mineral phases although none of the tested minerals (jarosite, goethite, hematite, and olivines) had the corresponding band.

Introduction: Existence of the 0.7-\mu m band in reflectance spectra of primitive asteroids, its similarity to the CM2 meteorites and Fe^{3+}-bearing phyllosilicates, and aqueous alteration on those asteroids as the cause were first pointed out by [1]. Some other primitive asteroids were shown to have other kinds of absorption bands around 0.63 and 0.9 \mu m similar to jarosite, goethite, and hematite possibly as the result of iron oxidization [2]. In this paper, those absorption bands are reanalyzed using spectral deconvolutions to characterize the band shapes and to compare them with those of known minerals.

Experimental: Reflectance spectra of the primitive asteroids (19, 54, 66, 102, 134, 187, 326, 407, 940, and 1467) were measured using a CCD spectrograph [3]. Reflectance spectra of six CM2 meteorite powders (ALH83100, ALHA81002, LEW90500, Mighei, Murray, and Murchison; <63 or <100 \mu m) were measured using the RELAB bidirectional spectrometer [4] at every 1 \mu m from 0.5 to 1.0 \mu m. Spectra of three septechlorites (lizardite, clinochrysoite, and chlorite; <125 \mu m) were measured at every 5 \mu m from 0.3 to 2.6 \mu m. Spectra of the same resolution for jarosite, goethite, hematite, and two olivines were taken from the RELAB database.

Method of Analysis: Each measured reflectance spectrum was converted to the approximate absorbance spectrum by taking its natural logarithm, which was then deconvolved into a background (linear to energy) and a series of modified Gaussians according to [5]. Two parameters of the background and three parameters (band center, width, and strength) of each absorption band were optimized for the best fit with each asteroid spectrum. For this study, the initial values of the background parameters were chosen so that the background is in contact with the measured spectrum at as many data points as possible. After deconvolving each asteroid spectrum, artificial random noise was added to the solution spectrum as a simulation of the noise introduced during the asteroid observation. Those spectra were deconvolved to estimate the error ranges (standard deviations) for the band parameters. This procedure is the same as the one used in our previous study on the S asteroids [6].

Results: The calculated band centers and widths of the primitive asteroids, CM2 meteorites, and tested minerals are plotted in Fig. 1. All the analyzed primitive asteroids have a broad, strong 0.7-\mu m band except for 326 Tamara that has a composite 0.7-\mu m band, which can be deconvolved into the 0.65 and 0.73-\mu m bands. All those asteroids also have a weak 0.6-\mu m band, and eight of them have the 0.9-\mu m band. The CM2 meteorites have similar 0.7 and 0.9-\mu m bands not far from those of the asteroids, the 0.6-\mu m band almost identical to that of asteroids, and an additional 0.8-\mu m band. Three septechlorites have the 0.7 and 0.9-\mu m bands as was shown by the pioneering work by [7]. Their band centers and widths are very close to those of the asteroids. Other minerals don't show any band corresponding to the asteroids except for the 0.65-\mu m band detected in the spectra of both 326 Tamara and hematite.

Discussion: Because the asteroid spectra have the limited wavelength range of 0.5-0.95 \mu m, the continuum background for them cannot be determined as accurately as for the laboratory spectra of the minerals tested in this paper. For this reason the CM2 meteorite spectra were measured almost in the same wavelength range (0.5-1.0 \mu m) and resolution (1 \mu m) to compare them with the asteroid spectra in a consistent way. Considering the errors due to the possible background errors, the band centers and widths of the 0.7 and 0.9-\mu m bands of the asteroids, CM2 meteorites, and the tested septechlorites are very close to one another. The 0.65-\mu m band of 326 Tamara may indicate existence of hematite or some other oxidized irons which were detected among other asteroids [2].
although its 0.9-μm band is much narrower than that of hematite. The cause of the 0.6-μm band of the asteroids and CM2 meteorites should be pursued in the future studies.

Acknowledgments: We thank M. E. Zolensky and the Meteorite Working Group for the meteorite samples, and C. M. Pieters and S. F. Pratt for their support of the spectral measurements at RELAB. RELAB is a multiuser facility operated under NASA grant NAGW-748. F. V. was a visiting astronomer, CTIO, NOAO. T. H. and F. V. were supported by NASA Planetary Astronomy Program. Part of this work was done while T. H. held a National Research Council-NASA/JSC Research Associateship.


Fig. 1. Examples of modified Gaussian deconvolutions of primitive asteroids, CM2 meteorites, and septechlorites. The residual error spectrum is shown in the top portion of each plot with an offset for clarity.

Fig. 2. Plot of the band centers and widths of primitive asteroids, CM2 meteorites, septechlorites, olivines, jarosite, goethite, and hematite. Standard deviations of asteroid points are shown as error bars. Points for the composite 0.7-μm band of 326 Tamara are indicated.