IRON OXIDE BANDS IN THE VISIBLE AND NEAR-INFRARED REFLECTANCE SPECTRA OF PRIMITIVE ASTEROIDS; Kandy S. Jarvis, Dept. of Geology, Wright State Univ., Dayton, OH 45417; Faith Vilas, NASA Johnson Space Center/SN3, Houston, TX 77058; Michael J. Gaffey, Dept. of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy NY 12181.

High resolution reflectance spectra of primitive asteroids (C, P and D class and associated subclasses) have commonly revealed an absorption feature centered at 0.7 μm attributed to an $Fe^{2+}$ - $Fe^{3+}$ charge transfer transition in iron oxides and/or oxidized iron in phyllosilicates [1,2]. A smaller feature identified at 0.43 μm has been attributed to an $Fe^{3+}$ spin-forbidden transition in iron oxides [3]. In the spectra of the two main-belt primitive asteroids 368 Haidea (D) and 877 Walkure (F), weak absorption features which were centered near the location of 0.60 - 0.65 μm and 0.80 - 0.90 μm [1] prompted a search for features at these wavelengths and an attempt to identify their origin(s).

CCD reflectance spectra obtained between 1982 - 1992 were reviewed for similar absorption features located near these wavelengths [1, 2, 4, 5, 6]. Figures 1, 2, 3 show the spectra of asteroids in which these absorption features have been identified. These spectra are plotted in order of increasing heliocentric distance. No division of the asteroids by class has been attempted here (although the absence of these features in the anhydrous S-class asteroids, many of which have presumably undergone full heating and differentiation should be noted). For this study, each spectrum was treated as a continuum with discrete absorption features superimposed on it. For each object, a linear least squares fit to the data points defined a simple linear continuum. The linear continuum was then divided into each spectrum, thus removing the sloped continuum and permitting the intercomparison of residual spectral features.

The most discernible feature is an absorption band centered at 0.65 μm of width ranging from 140 - 245 Å. Analogues for this feature are seen in spectra of the CM2 carbonaceous chondrites Cold Bokkeveld and Murray [1]. The depth, spectral placement of the beginning and end of the feature, width and area of the feature were all checked for correlations with properties of the asteroids such as albedo [7], distance [8,9] and classification [10]. No correlations were observed except for a weak trend of decreasing depth of feature with increasing heliocentric distance. Several minerals possess this 0.65-μm absorption feature, which has been associated with charge-transfer bands or spin-forbidden bands of transition metal elements. The source of this band is most likely $Fe^{2+}$ or $Fe^{3+}$ or both. Other possible elements such as $Cr^{3+}$ and $Ti^{3+}$ are much rarer than iron in most meteorites. (There is also a solar absorption band at 0.6563 μm, but it is unlikely to generate such a comparatively broad feature.) Based upon spectral shape, the most probable sources of this feature are goethite or hematite. These are strong possibilities due to their association with aqueous alteration of iron-bearing minerals (the assumed cause of the 0.7-μm absorption feature[1,2]), their absorption band locations, and their association with jarosite (a proposed cause for the 0.43-μm feature [3]). Many of these spectra also have a feature located near 0.8 - 0.9 μm. Goethite has an absorption feature at 0.65 μm and at 0.90 μm, while hematite, the anhydrous version of goethite, has bands located at 0.66 and 0.85 μm. Townsend [11] has proposed that the spectral placement of the longer wavelength feature could be used as a discriminator between the two minerals for terrestrial remote sensing. Presumably, the same may be true for asteroid spectra. Extreme care must be exercised, however, as telluric water absorption features become prominent near 0.9 μm and, if not fully compensated during the data reduction, will affect the identification and interpretation of these features.

A third feature found nested in the broader 0.65-μm feature in some of the asteroid spectra is a small peak located at ~0.63 μm. The apparent double absorption feature at 0.60 μm and 0.66 μm is presently unexplained. The variations in height of the feature in both spectra of 1 Ceres suggests surface mineralogical variations evident throughout its rotational period.

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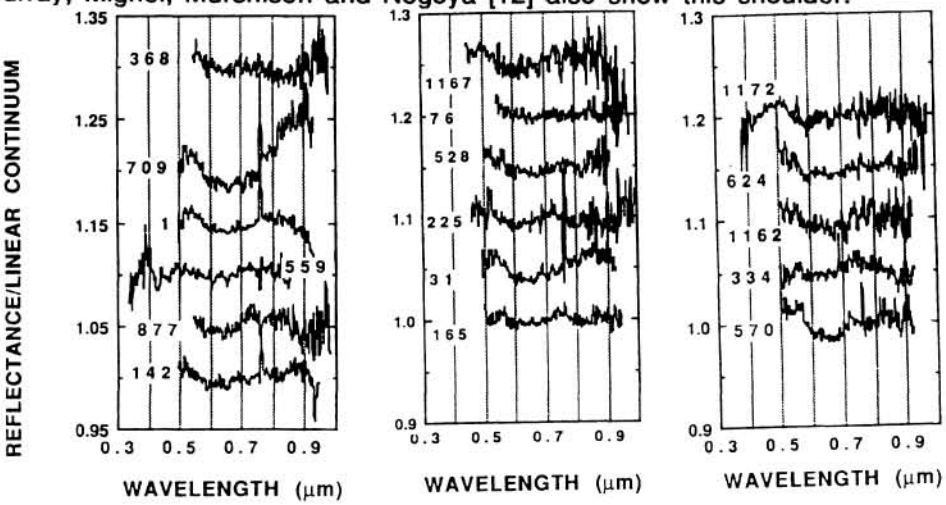
In some spectra displaying the prominent 0.70-μm absorption feature, a shoulder occurs at ~0.63 μm (Fig. 4). This shoulder may be the result of the 0.65-μm feature superimposed on the 0.70-μm feature, and represent a change in the aqueous alteration event sequence in solar system history between those asteroids that have spectra showing only the 0.65-μm feature and those also showing the 0.7–μm feature. Laboratory spectra of CM2 meteorites Cold Bokkeveld, Murray, Mighei, Murchison and Nogoya [12] also show this shoulder.




Figs. 1, 2, 3 Reflectance spectra with ascending heliocentric distance.

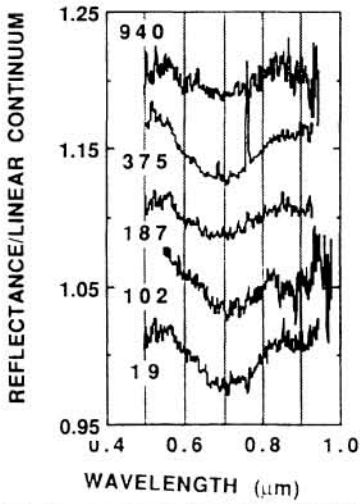



Fig. 4 0.7-μm Feature with 0.63-μm Shoulder

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