IRON OXIDE BANDS IN THE VISIBLE AND NEAR-INFRARED REFLECTANCE SPECTRA OF
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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
Fe²⁺ - Fe³⁺ 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 Fe³⁺ 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 is associated with charge-transfer bands or spin-forbidden bands of transition
metal elements. The source of this band is most likely Fe²⁺ or Fe³⁺ or both. Other possible
elements such as Cr³⁺ and Ti³⁺ 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.
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.

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