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# Hydrated silicates on main-belt asteroids: Correlation of the 0.7- and 3-micron absorption bands

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## Abstract

The presence of water and/or hydrated minerals on asteroids constrains solar system formation models and helps our understanding of the relationship of asteroids to meteorites. We have collected observations of main-belt asteroids at 0.7 and 3 microns to clarify the relationship between these bands and determine if the 0.7-micron band is a reliable proxy for hydrated minerals on asteroids. We find that if the 0.7-micron band is seen, the 3-micron band is almost always there as well. However, even when the 0.7-micron band is ***not*** seen, nearly 50% of the asteroids have the 3-micron band, and thus there are hydrated minerals. The presence of the 0.7-micron band places a lower limit on the number of asteroids with hydrated minerals. The correlation of these two bands differs between the C-complex and X-complex taxonomic groups as defined by DeMeo [1], and interesting trends are found. On more distant asteroids, the 3-micron absorption band may be due to ice rather than hydrated silicates [2, 3, 4].

## 1. Introduction

The distribution of water in the asteroid belt puts strong constraints on any parent body heating events, since water- and hydroxyl-bearing minerals (hydrated minerals) become dehydrated and destroyed at temperatures well below melting [5]. For carbonaceous chondrites and the C-class asteroids, their presumed parent bodies, hydrated minerals are nearly the only features identifiable in their reflectance spectra. Observations of the strong absorption band at 3 microns are clearly diagnostic of hydrated minerals, but the 3-micron region is more difficult to observe through the Earth's atmosphere. The associated iron charge-transfer band at 0.7 microns is much easier to observe, and has been used as a proxy indicator of hydration [6].

## 2. Observations

We have collected relative reflectance observations at 0.7 and 3 microns of 156 asteroids, some new observations and some previously published. Most of these objects are low-albedo main-belt objects, but a few higher albedo asteroids are also included. The large visible surveys include many spectra that show the 0.7 micron absorption feature. Most 3-micron spectra since 2000 were taken at the NASA Infrared Telescope Facility (IRTF) using SpeX. These higher resolution and higher quality spectra sometimes contradict earlier observations. For example, we observed asteroid 554 Peraga and find that it has a 3-micron absorption band, contrary to the conclusion of Lebofsky [7], who used an overly conservative estimate of the continuum and thermal emission. However, because asteroids rotate, and may not be homogeneous, spectra taken at different times that disagree may also reflect real surface variability.

## 3. Correlation of hydration bands

Among the 156 asteroids observed at both 0.7 and 3 microns, about 30% have both absorption bands. About 35% have the 3 micron band, but do not have the 0.7 micron band. The remaining 35% do not have either absorption band. Almost none have the 0.7 micron band without the 3 micron band, consistent with both these bands arising from hydrated minerals. These few objects will be discussed. Figure 1 shows examples of combined spectra from an asteroid with both hydration bands (91 Aegina), one with the 3 micron band, but not the 0.7 micron band (475 Hedwig) and one with neither band (838 Seraphina). Hiroi [5] has shown that moderate heating can eliminate the 0.7 micron band, but not the 3 micron band. Rotational variation might also explain seeing hydrated minerals on one part of an asteroid and not on another.

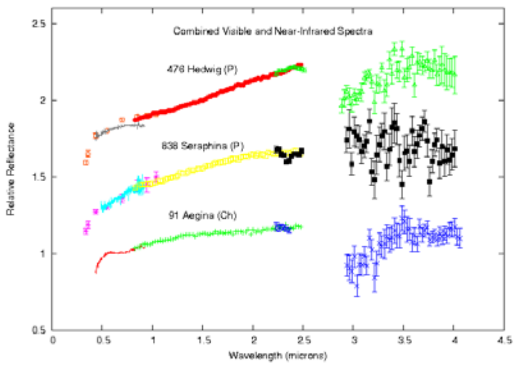


**Figure 1:** Examples of combined visible and near-infrared asteroid spectra. Asteroid 475 Hedwig has the 3-micron band but not the 0.7-micron band. Asteroid 838 Seraphina has neither band. Asteroid 91 Aegina has both bands. Available visible spectra are plotted, normalized to 1.0 at 0.55 microns. The SpeX prism and LXD spectra are matched in the region of overlap, and were taken closely in time. The thermal emission has been modelled and removed. The 3 micron band is seen as a drop in reflectance between 2.5 and 3.5 microns.

## 4. Trends

More than 85% of the 156 asteroids in our sample are either C-complex or X-complex objects using the Bus-DeMeo taxonomy [1]. The C-complex and X-complex objects show distinct patterns in the correlation of the hydration bands. About 80% of the C-complex asteroids have the 3 micron band, and about 70% have the 0.7 micron band. The X-complex asteroids rarely have the 0.7 micron band, but about half of them do have the 3-micron band. We see trends in both groups with asteroid size, but no apparent trends with semi-major axis. Hydrated objects are found from 2-3.5 AU in both taxonomic groups.

## 5. Summary and Conclusions

The absorption bands at 0.7 and 3 microns are related indicators of hydrated minerals. The 0.7 micron band has been used as a proxy for the 3 micron band. We find that if the 0.7 micron band is seen, the 3 micron band is almost always present as well. Even when the 0.7 micron band is *not* seen, the 3 micron band is present in about half of the objects sampled in the C- and X-complex taxonomic groups. The 0.7 micron band thus provides only a lower limit on the number of hydrated asteroids in the main belt. The 3 micron band may result from ice grains instead of or in addition to hydrated minerals on more distant objects [2, 3, 4].

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