EPSC Abstracts
Vol. 6, EPSC-DPS2011-377, 2011
EPSC-DPS Joint Meeting 2011

Hydrated minerals on asteroids in the Main Belt

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Introduction

Knowledge of the hydrated mineral inventory on the asteroids is important for deducing the origin of Earth's water, interpreting the meteorite record and unravelling the processes occurring during the earliest times of our Solar System history.

Observations show that hydrated minerals are common in the mid/outer main asteroid belt. The mechanisms responsible for such hydration are not clear, and the rotational variations observed in several diagnostic absorption features suggest that hydration was uneven. The presence of hydrated minerals on a body can be explained if that body had water ice and a source of heat to melt that ice. Heating sources could be both the ^{26}Al (if the heat is present in the early formation times) and the heat generated by a collision. In the meteorite collection, hydrated minerals are found mostly among the carbonaceous chondrites, in particular the CI, CM, and CR groups.

These meteorites have mineralogies indicative of low levels of metamorphism (1200 ºC) and evidence for aqueous alteration [1][2]. The CM and CI carbonaceous chondrites typically contain 5 – 15% H_2O/OH by weight, some of them containing even more than 20%. The CI chondrites are composed almost entirely (>=90 vol %) of fine-grained phyllosilicates, though other hydrous and hydroxylated minerals are also present.

The phyllosilicates, or sheet silicates, are an important group of hydrated minerals that includes the micas, chlorite, serpentine, talc, and the clay minerals. Clay minerals are one of the primary products of chemical weathering and one of the more abundant constituents of sedimentary rocks.

Two spectral regions have been the focus for hydrated mineral studies on asteroids: the 3µm region spanning 2.4 - 3.6µm, and the visible region between 0.4 - 0.9µm.

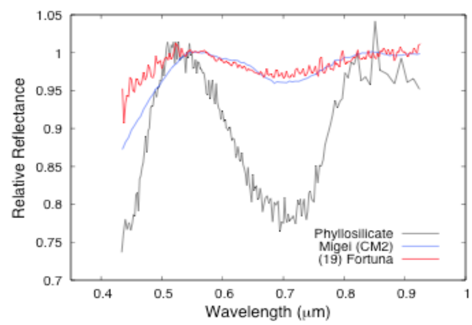

Figure 1. Three different spectra showing the absorption band at 0.7µm. The asteroid (19) Fortuna, a phyllosilicate antigorite (from [4]), and a CM2 carbonaceous chondrite. All the spectra are normalized to unity at 0.55µm.

Spectra of some main belt asteroids show an absorption feature centred near 0.7µm with a width of roughly 0.25µm, attributed to a Fe^{2+} --> Fe^{3+} charge transfer transition in oxidized Fe found in phyllosilicates [3]. Figure 1 shows examples of this feature in the spectra of a main belt asteroid, a carbonaceous chondrite and a phyllosilicate.

Results

In order to determine how significant and homogeneous is the presence of hydrated minerals in the surface of asteroids we have started a long-term program to obtain visible reflectance spectra of main belt asteroids with the 0.7µm absorption band previously detected. Our observations are done using CAFOS at the 2.2m telescope in the Calar Alto Astronomical Observatory. To search for any variation in the position, width, and depth of this absorption band, and correlations with other physical/dynamical parameters of the object, we obtain a spectrum every quarter of its full rotational period. Here we present the results for a preliminary set of 60 asteroids.

References

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