Alteration on asteroids: Insights from CM/CI meteorite mineralogy and midwave-infrared spectroscopy

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Introduction: Primitive, dark asteroids have few spectral features in the visible and near-infrared (NIR) in the 0.5–2.5 µm region. Traditional classification of these asteroids has relied mainly on the presence of a 0.7 µm charge-transfer band and the slope of the spectrum in the NIR. While the 0.7 µm charge-transfer band has been attributed to phyllosilicates, the presence of this band is uncorrelated to total amount of phyllosilicates in well studied CM/CI meteorites. It is, therefore, not possible to identify specific compositions or water content of asteroids using this wavelength region. The work presented here seeks to augment the understanding of the composition of dark asteroids by studying CM/CI meteorites in the mid-infrared (MIR, 8 to 25 µm). Observed compositional trends as a function of alteration in the MIR spectra of well-studied CM/CI meteorites are used as a basis for interpreting MIR spectra of asteroids.

MIR Studies of CM/CI meteorites: CM and CI meteorites have well understood mineralogical variations. These meteorites underwent a water-rock reaction (aqueous alteration) on their parent bodies. This reaction converted their initially anhydrous silicates into hydrated phyllosilicates. In many meteorites, this process is incomplete. As such, the meteorites are complex mixtures of phyllosilicates, anhydrous silicates, and accessory phases. The MIR spectra of the CM/CI meteorites reflect this complexity. Our studies indicate that features in the 10–13 µm region are combination features of Mg-rich phyllosilicate absorptions and anhydrous olivine. The position of this feature is directly correlated to total abundance of phyllosilicates and therefore can be used remotely to determine the amount of alteration an asteroid has experienced.

Preliminary Studies of Dark Asteroids: Preliminary studies of dark asteroids using archived Spitzer Space Telescope Infrared Spectrograph data show that some dark asteroids have features that are similar to the least altered CM/CI meteorites. Four Themis family asteroids, including (24) Themis, and three Cybele asteroids, including (65) Cybele, have been studied. These asteroids typically show a 10–13 µm feature similar in position to those of least-altered CM/CI meteorites. Variation in the position of this feature is also observed.

Ongoing Work: A survey of dark asteroids using archived Spitzer data is ongoing. Using the results from the CM/CI meteorites studies, it is possible to interpret the spectra of dark asteroids in the context of the meteorite mineralogy. The first set of asteroids studied are the Bus Cg, Ch, and Cgh asteroids which are thought to have phyllosilicates because of the presence of the 0.7 µm charge-transfer band in the NIR. Spectral features in the MIR should also reflect the presence of phyllosilicates which may allow the identification of specific compositions and amount of phyllosilicates present on these bodies.

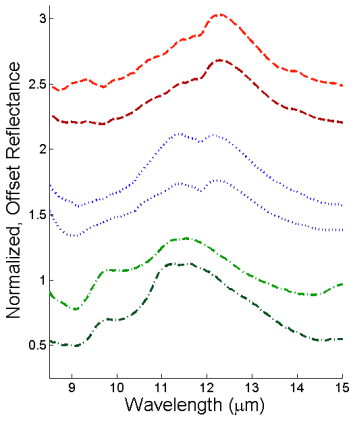

Figure: Six normalized, offset meteorite spectra top to bottom: Murchison (CM2), QUE 97990 (CM2), Mighei (CM2), Y-791198 (CM2), SCO 06043 (CM1), and Orgueil (CI1). The color represents the category of degree of alteration: red is least altered, blue is intermediate, and green is highly altered.