SPECTRAL FEATURES IN C AND C-LIKE ASTEROIDS AND THE POSSIBLE PRESENCE OF PHYLLOSILICATES. D. R. Ostrowski[1], D. W. G. Sears[1,2], and K. M. Gietzen[1], C. H. S. Lacy[1,3], [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, Ar 72701, USA (dostrow@uark.edu), [2]Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, Ar 72701, USA, [3]Department of Physics and Astronomy Sciences, University of Arkansas, Fayetteville, AR 72701, USA.

Introduction: Main belt asteroids (MBA) and near Earth asteroids (NEA) are classified into 26 discrete classes. The NEAs are a small fraction of the total asteroid population. For the NEAs alone there are about 4500 known, with an even smaller fraction of these that have spectra that can be classified. The large unknown population of asteroids has a need to be classified, in the mineralogical sense. For classification the mineralogically important spectral range is 0.8 – 2.5 μm. This can give the scientific community an idea of how asteroids are formed.

The C and C-like asteroids make up about 50% of the MBAs. The composition of these asteroids is unknown. It has been shown by spacecraft flybys and telescopic observations that C asteroids are possibly rubble piles. In recent experimental observation it has been suggested that these bodies generally considered to be featureless, do contain features in their relatively flat spectra [1].

Experimental: To date we have obtained seven observing runs between 2004 and 2006 on NASA's IRTF that has yielded spaectra of 35 asteroids. The spectral range observed is from 0.8 μm to 2.5 μm. The spectra were coupled with the visible wavelengths (0.4-0.9 μm) from the MIT SMASS [2-9]. The data is compared against a phyllosilicate database to check for the possible connection.

A phyllosilicate database has been built. It is separated by the three layer types; 1:1, 2:1, and 2:1:1. Spectra for this database has been acquired from the USGS spectral library [10].

Results: Of the asteroids observed, five are C and six are C-like. Figure 1 depicts the visual and infrared spectra of the C asteroids obtained and Fig 2 does this for C-like asteroids. The noise in the spectra at 1.4 and 2.0 μm is where the possible absorption features for phyllosilicates are present.

C Chondrites: The carbonaceous chondrites most closely resembling the C asteroids in their reflectivity spectra are the CI and CM chondrites, which are those most close to solar composition. Researchers agree that they consist essentially of phyllosilicates, but there is considerable uncertainty as to their exact nature; chlorite, serpentine, mica, montmorrillonite, and many others have been mentioned [11]. Figure 3 displays the spectra of CI and CM chondrites [12].

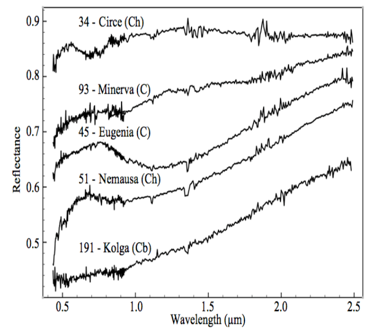

Figure 1: Visible and infrared spectrum of the observed C asteroids. Spectra are randomly stacked for visual comparison reasons.

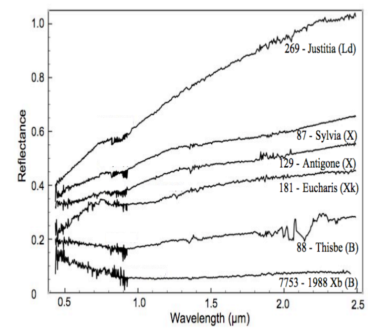

Figure 2: Visible and infrared spectrum of the obserbed C-like asteroids. Spectra are randomly stacked for visual comparison reasons.

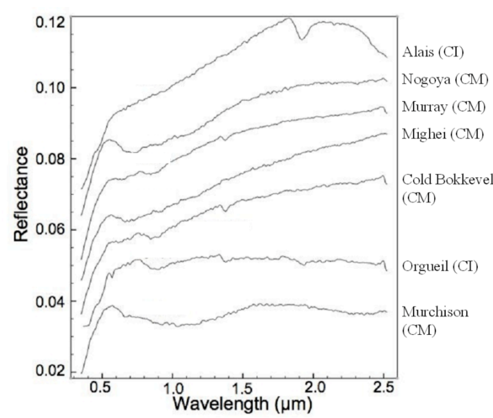

Figure 3: Visible and infrared spectra of CI and CM meteorites. The shape of the spectra is similar to that of the C and C-like asteroids.

Spectra of Phyllosilicates: The phyllosilicates are divided into three layer types: the 1:1, 2:1, and 2:1:1, which are composed of tetrahedral and octahedral sheets stacked on top of each other. As seen in Fig 4 there are absorption features at 1.915, 1.985, and 2.315 µm that identify the structural type of 2:1, 2:1:1, and 1:1 respectively.

There are two sources for the differences in the spectra. First is the already stated three different layer types that each have identifying absorption features. The other difference in the spectra is the shift in the absorption features of the layer type identifiers. This is due to the primary metal element in each of the clays.

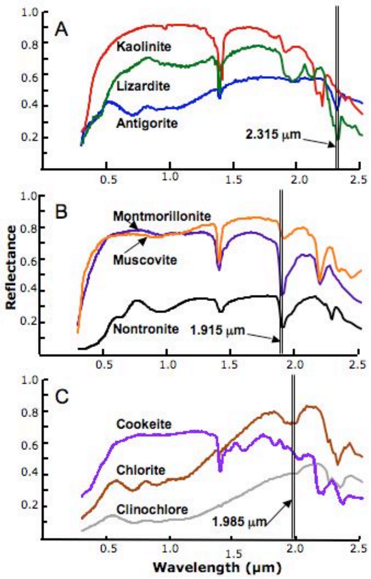

Figure 4: Visible and infrared spectrum of phyllosilicate clays. A range of metal elements were selected to depict both structural and elemental differences. a. The spectrum of the structure types 1:1. b. The spectrum of the structure type 2:1. c. The spectrum of the structure type 2:1:1.

Discussion: Visually the spectra for the C and C-like asteroids look similar to that of the CI and CM chondrites. The CI and CM continuum ratio (Fig 5) fall directly in line with that of the asteroids. This would mean that the C and C-like asteroids could be parent bodies for the CI and CM meteorites.

Studying the differences in continuum slope for the 1.8-2.5 µm versus the 1.0-1.75 µm a definite trend is seen (Fig 5). All the asteroids line up together and are parallel to the phyllosilicates. The difference is in the 1.8-2.5 µm continuum, which for the asteroids increase with wavelength. For the phyllosilicates the continuum between 1.8 ands 2.5 µm drops drastically (Fig. 4). One possibility for the difference between the asteroids and the phyllosilicates could be structural water. It has a very strong absorption feature that can depress the spectra around it. This would mean that the C and C-like asteroids are depleted in or contain no forms of water in their mineralogy.

Comparing absorption bands is a method of connecting the mineralogy of the asteroids to that of the phyllosilicates. When the above stated phyllosilicate identifier bands were applied to the asteroid spectra the lack of absorption bands was apparent. The phyllosilicates contain strong bands where the asteroids have very weak bands that are covered by noise in the spectra. This could be the result of one or multiple alteration processes.

The alteration processes that are possibly affecting C asteroids are dehydration, space weathering, and impacts. Their importance is the ability to remove both hydrated and structural water. All these methods and the loss of water will cause a flattening of the spectra. This could account for the difference in the phyllosilicate and asteroid spectra.

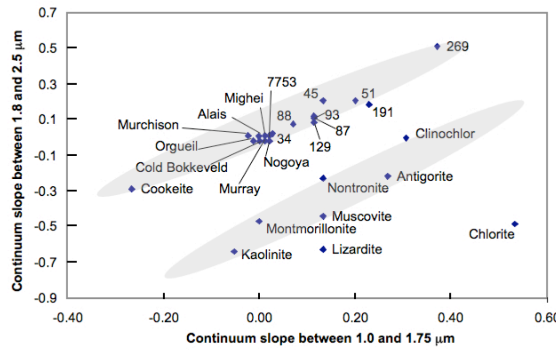

Figure 5: Continuum slope comparison between the C and C-like asteroids, CI and CM meteorites, and phyllosilicates.

Conclusion: While there appears to be a link between CI and CM chondrites and the C asteroids, the nature of this linkage is unclear. Even more problematic is the difference between terrestrial phyllosilicates and the asteroids and meteorites. A difference in the amount and distribution of water between the terrestrial phyllosilicates and the C chondrites and C asteroids might explain the difference, and further experimentation will address this.

References: [1]Kelley, M. S. et. al. (2007) *LPSC XXXVIII, 2366*. [2]Binzel, R. P., et.al. (2001) *Icarus, 151*, 139-149. [3]Binzel, R. P., et.al. (2004) *MAPS, 39,* 351-366. [4]Binzel, R. P., et.al. (2004) *Icarus, 170,* 259-294. [5]Burbine, T. H. (2000) *Ph. D. Thesis, MIT*. [6]Burbine, T. H. and Binzel, R. P., (2002) *Icarus, 159,* 468-499. [7]Bus, S. J. (1999) *Ph.D.Thesis, MIT*. [8]Bus, S. J. and Binzel, R. P. (2002) *Icarus, 158,* 106-145. [9]Bus, S. J. and Binzel, R. P. (2002) *Icarus, 158,* 146-177. [10]Clark, R. N. et. al. (2003) *USGS Digital Spectral Library, splib05a*. [11]Brearley A. J. and Jones, R. H. *Rev. Mineral.* 36, ch 3. (1998). [12] Gaffey, M. J. (1976) *JGR 81*, 905-920.