Damage Induced by Raman Excitation Laser during Analysis of Carbonaceous Chondrites. C. J. Bennett[1,2,3], B. Ferrari[3], A. LeBleu-DeBartola[3], C. Pirim4, J. Noble[4], Y. Carpenter[4], C. Focsa[4], A. Schulte[3], D. Britt[2,3], [1]Radiation Effects on Volatiles and Exploration of Asteroids and Lunar Surfaces (REVEALS, PI: Thom Orlando), [2]Center for Lunar and Asteroid Surface Science (CLASS, PI: Dan Britt), [3]Department of Physics, University of Central Florida, Orlando, FL, [4]Université de Lille, Lille, France (Christopher.bennett@ucf.edu).

Introduction: Raman spectroscopy and micro-Raman spectroscopy are commonly utilized to analyze both terrestrial and extraterrestrial materials. However, many extraterrestrial materials, such as carbonaceous chondritic meteorites, have very low albedos, which indicates that the majority of light is absorbed by the material, which can cause considerable heating of the material when studied by Raman spectroscopy, even when very low laser powers are used. Several authors have urged the importance of utilizing laser powers of less than 0.4 mW to minimize damaging carbonaceous meteorite samples. Here, we report damage at levels as low as 0.15 mW.

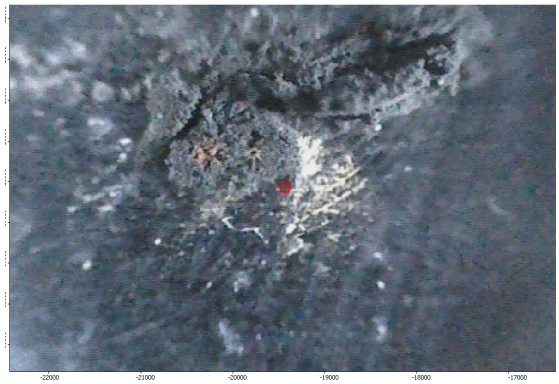

Figure 1: Visible image of the damage caused on the Allende (CV3) meteorite when exposed to 50 mW of laser power from that 1064 nm (Image span approximately 0.5 mm across).

Experimental Set-Up: We performed Raman experiments using two separate Raman instruments. Firstly, the iS50 Raman module from ThermoFisher Scientific installed within an iS50R FTIR spectrometer which operates using a 1064 nm laser at a power of 50 mW and spot size of approximately 50 microns. Secondly we utilized a Renishaw 1000B microRaman spectrometer utilizing two separate lasers at 514.5 nm (150 mW) and 633 nm (50 mW), and tested the power response from (0.1% to 10%) when utilizing 5X, 20X and 50X objectives. With the highest magnification setting, the spot size here is <1 µm.

We analyzed the stability and alteration of collected spectra obtained from samples of the Murchison (CM2), Jbilet Winselwan (CM2), Tagish Lake (C2) and Allende (CV3) carbonaceous chondritic meteorites.

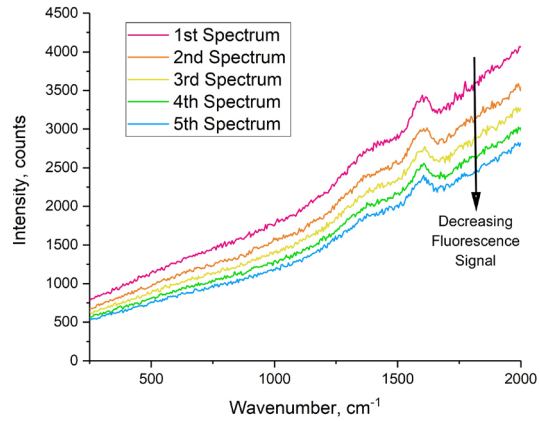

Figure 2: Five successive Raman spectra taken on the same area of a Murchison (CM2) meteorite when exposed to 514.5 nm laser at only 0.1% power (0.15 mW), in conjunction with a 20X objective.

Results and Discussion: With the 1064 nm laser, even at the lowest power setting (50 mW), it was not possible to obtain spectra from the Allende sample without visibly damaging the sample (Figure 1).

At both 514.5 nm and 633 nm, there was significant fluorescence in all meteorite samples, likely due to the presence of polycyclic aromatic hydrocarbons (PAHs) and related compounds. The 633 nm laser induced significantly more fluorescence than the 514.5 nm laser and was not used for the majority of this work. With the 514.5 nm laser, and the 50X objective, some initial damage was observed on most meteorites even using only 0.1% laser power (0.15 mW). Carbonaceous chondrites that have been exposed to lower peak metamorphic temperatures were generally more susceptible to laser damage than those that had experienced higher temperatures, such as Allende. In some cases, damage was found at laser powers of 0.1% using the 20X objective (e.g., for Murchison, as in Figure 2).

Utilizing higher laser powers caused more pronounced fluorescence depression (associated with the destruction of PAHs), and the production of several new bands in the lower wavenumber region.

Experiments were performed in order to determine whether different regions were being sampled due to sample-drift or regions from lower layers becoming exposed and sampled. Both possibilities were ruled out, indicating these spectral features are associated with the original material and the formation of new species.