**REFLECTANCE SPECTRA OF HEATED CARBONACEOUS CHONDRITES CM2 MURCHISON AND JBILET WINSELWAN IN THE 350-2500 NM REGION.** S. Sidhu[1], P. Mann[1], D. Applin[1], and E. Cloutis[1]. [1]Centre for Terrestrial and Planetary Exploration (C-TAPE), University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, Canada R3B 2E9; sidhu-s13@webmail.uwinnipeg.ca.

**Introduction:** Carbonaceous chondrites (CCs) are primitive objects which provide a unique window into the history of the solar system [1, 2, 3]. Many CCs display evidence of aqueous alteration followed by thermal alteration, varying between slightly altered to heavily altered, and lightly heated to heavily heated (many hundreds of °C) [4, 5, 6].

Asteroids (162173) Ryugu and (101955) Bennu – targets of JAXA's Hayabusa 2 mission and NASA's OSIRIS-REx mission, respectively – display spectral evidence of aqueous alteration and thermal metamorphism in the form of a weak absorption band centered near ~2.7 µm [7, 8]. Orbital modelling of both asteroids also suggests that they likely experienced heating during close passes by the Sun [9, 10].

We acquired and analyzed reflectance spectra of two CM2 CCs: Murchison and Jbilet Winselwan, as well as a simulant Murchison mixture. Both pre- and post-heated (1200ºC) reflectance spectra of the samples were collected. Characterizing the spectral characteristics of heated meteorites can help us understand and constrain the degree of heating experienced by aqueously- and thermally-altered CCs.

**Methods:** We heated and analyzed three samples in this experiment: Murchison, Jbilet Winselwan, and WMM, a simulant Murchison mixture (<63 µm) which was created by mixing various representative end-member materials. WMM composition is as following: 85 wt. % ASB267, a dark serpentine to represent CM phyllosilicates, 5 wt. % SHU102 (shungite) to represent organic phases, 5 wt. % TRO203, synthetic troilite to represent sulfides, and 5 wt. % MAG200, nanophase maghemite.

Murchison and Jbilet Winselwan were hand ground and dry sieved to powders of <63 µm grain size using an alumina mortar and pestle. The samples were heated at 100ºC increments from ambient to 1200ºC under an anoxic, dry nitrogen (Praxair NI 4.8T) environment. The system was set to ~1.3 mb and re-purged every morning. Samples were heated for 1 week from increments 100-1000ºC, 2 hours at 1100ºC, and 1 hour at 1200ºC due to the oven's constraints. After each increment, the samples were taken out, reflectance and XRD data were collected, and the samples were put back into the oven for the duration of the next increment.

Visible to near IR (350-2500 nm) reflectance data were collected with an Analytical Spectral Devices (Boulder, Co) FieldSpec Pro HR spectrophotometer with a spectral resolution of between 2 and 7 nm. Spectra were collected at a geometry of $i$ = 30º and $e$ = 0º with the incident light being provided by an in-house quartz-tungsten-halogen collimated light source. Samples were measured relative to a Spectralon® 99% diffuse reflectance standard and corrected for minor (less than ~2%) irregularities in its absolute reflectance.

**Results:** Reflectance spectra of the three sample suites are displayed in Figures 1, 2, and 3.

*Murchison* (**Figure 1**): Several variations in spectra as a result of temperature are evident. Around 400ºC, the spectra start displaying $Fe^{3+}$ oxyhydroxides associated features, including a steep red slope in the visible region. Absorption features ~870 nm are visible starting at ~500-600ºC and are visible until 1000ºC. An absorption feature around ~1700 nm is visible in the spectra for 700-900ºC. Spectra generally increase in reflectance up to 900ºC, after which they darken substantially, resulting in relatively dark and featureless spectra beyond 1100ºC. An absorption band ~1900 nm is present starting at 400ºC, and disappears ~1000ºC.

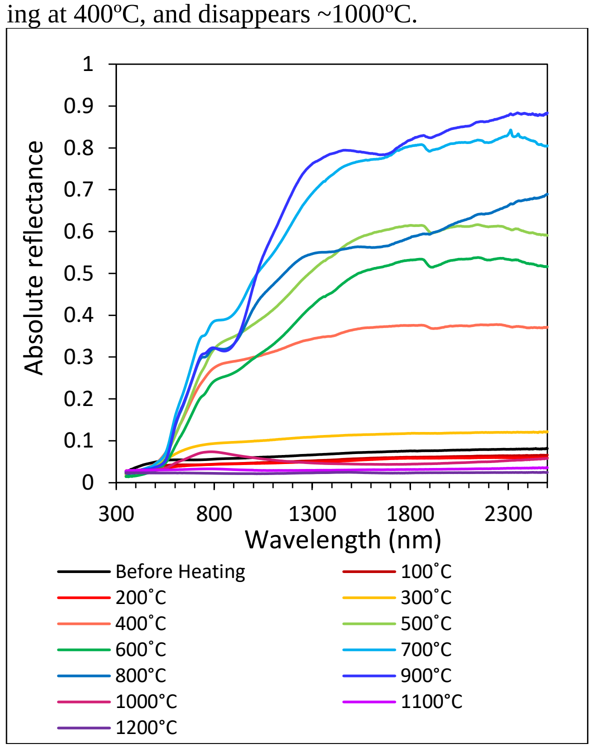


**Figure 1**: Reflectance spectra of heated Murchison powder (<63 µm) over the 350-2500 nm region.

*WMM* (**Figure 2**): Spectra show little variation up to ~400ºC, beyond which $Fe^{3+}$ oxyhydroxides-associated features, including an increasing red slope under 700 nm and an absorption feature ~870 nm can be detected. Serpentine-associated absorption bands ~1400 and ~2320 nm are present up to ~700ºC. Spectra become brighter up to 700ºC, after which they darken. The resulting end-spectrum at 1200ºC is olivine-like with a broad absorption band centered ~1000 nm.

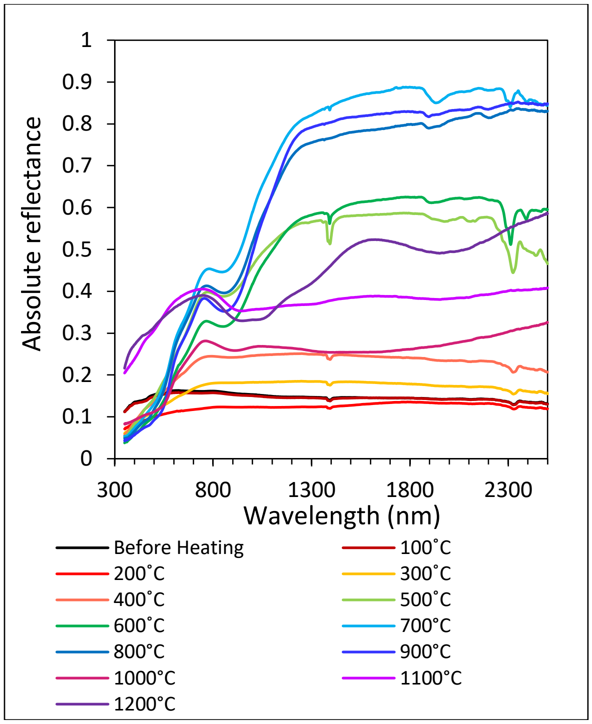


**Figure 2**: Reflectance spectra of simulant Murchison powder, WMM (<63 μm), over the 350-2500 nm region.

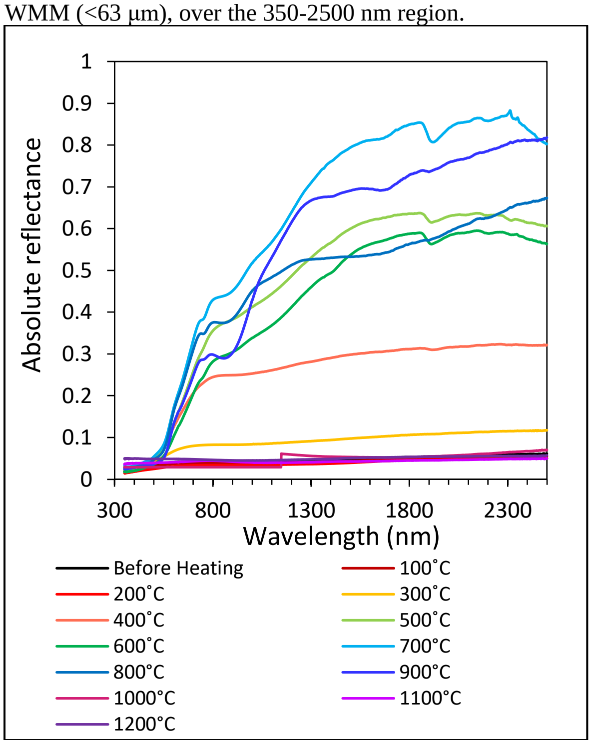


**Figure 3**: Reflectance spectra of heated Jbilet Winselwan powder (<63 μm) over the 350-2500 nm region.

*Jbilet Winselwan* (**Figure 3**): Spectra display little change up to 300ºC. At 400ºC, the spectra increase in brightness, and display $Fe^{3+}$ oxyhydroxides features such as a steep red slope below ~700 nm. Generally, the spectra become increasingly brighter until 700ºC, after which the spectra start to darken. Absorption features ~870 nm are most prominent at 700-900ºC, which can also be associated with $Fe^{3+}$ oxyhydroxides. Spectra from 400-700ºC display an absorption feature ~1900 nm, which gets more prominent with increasing temperature. Spectra of 700-900ºC also display a slight absorption band ~1700 nm. Spectra of 1000-1200ºC are very dark and featureless.

**Discussion:** Results of this study demonstrate that spectral variation induced by temperature are evident over the 350-2500 nm region in Murchison and Jbilet Winselwan spectra. XRD analysis confirm that these results are due to mineralogical changes. Devolatilization of organic phases also resulted in spectral changes observed.

Spectral variations observed are applicable to short-term heating events, as the heating duration for the experiment ranged from days to hours. Furthermore, the anoxic environment under which these experiments were conducted represents only one set of environmental conditions under which a carbonaceous chondrite may have undergone heating. Regardless, our results indicate that spectra in the 350-2500 nm can provide insight into any heating events which may have occurred on serpentine-rich asteroids, and constrain the environmental conditions (such as oxygen fugacity).

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