THE EFFECTS OF VARYING ENVIRONMENTAL CONDITIONS ON THE EMISSIVITY SPECTRA OF METEORITES. I. R. Thomas[1], N. E. Bowles[1], K. L. Donaldson Hanna[1], H. C. Connolly Jr.[2,3,4], M. Killgore[4] and D. S. Lauretta[4], [1]Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, UK (thomas@atm.ox.ac.uk), [2]Dept. Physical Sciences, Kingsborough Community College of CUNY, Brooklyn NY 11235 & Dept. Earth & Environmental Sciences, The Graduate Center of CUNY, 365 5th Ave., New York, New York, USA; [3]Dept. Earth & Planetary Sciences, American Museum of Natural History, New York, NY 10024 USA; [4]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA.

Introduction: With NASA's OSIRIS-REx mission due to launch to asteroid 101955 Bennu (preliminary designation 1999 RQ36) in 2016, preparations are well underway [1]. To meet one of the mission goals of mapping the global geological characteristics of the asteroid, the OSIRIS-REx Thermal Emission Spectrometer (OTES) will map the asteroid's surface to derive thermophysical and compositional properties [1], by comparing spectra to those of known samples measured in the laboratory. OTES is an infrared mapping spectrometer operating from 2500-200cm^{-1} (4-50µm) with 10-cm^{-1} resolution, and is capable of making one measurement every 2 seconds to build up a spectral map of the entire surface including the sampling site [1]. Previous laboratory studies have shown that samples can exhibit differences in emission spectra due to the environment (e.g. surface pressure and illumination conditions) in which they are measured [e.g. 2-4], however the magnitude of these variations are unknown for asteroidal conditions. The aim of this work is to determine whether laboratory samples of Bennu analogue materials need to be measured in environmental conditions similar to the hypothesized conditions on the asteroid's surface for the correct interpretation of returning data from OTES: to do this, the Lunar Environment Chamber in the Planetary Spectroscopy Facility at Oxford University [4] was used to simulate the expected conditions on Bennu while a selection of particulate meteorite samples was measured.

Thermal Environment: The aim of the simulated asteroid environment (SAE) measurements is to induce a temperature gradient in the near-surface of the sample that matches as closely as possible the hypothesized conditions on the surface of an airless body like Bennu. Such a gradient is induced due to the thermal environment of the asteroid; the surface is heated by the Sun, which is typically capable of penetrating several centimetres [e.g. 3], but the surface re-radiates in the thermal infrared. This radiation is emitted only from the top few hundred microns, cooling the very top layers, and hence a gradient is induced. Without an atmosphere, convective heat transport does not equalize this gradient as it would on Earth, where the interstitial atmospheric gases between regolith grains would dominate radiation and conduction, thus it is important to simulate these conditions in the laboratory.

Experiment: The Lunar Environment Chamber (Figure 1), described in more detail elsewhere [4], consists of a vacuum chamber capable of maintaining a pressure of <1 x 10^{-4} mbar (typically around 1 x 10^{-5} mbar during a measurement). Within the chamber, ~5g of sample is placed in a cup capable of being heated to 450K and is surrounded by a radiation shield that can be cooled to temperatures <150K. A solar-like lamp illuminates the samples, heating up the surface, simu-

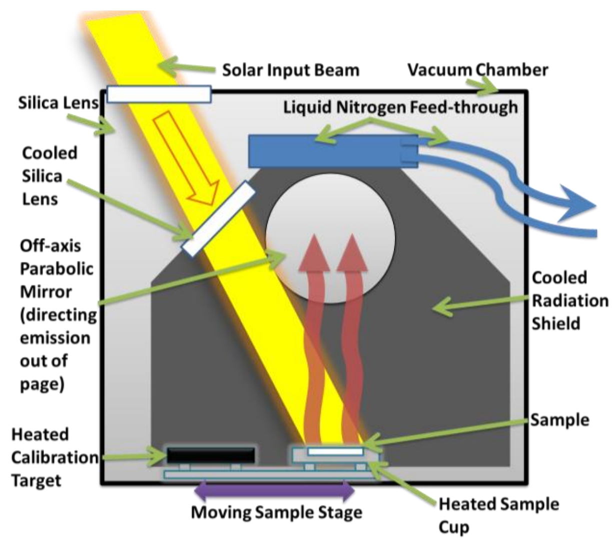

Figure 1: Schematic layout of the Lunar Environment Chamber in the Planetary Spectroscopy Facility at Oxford University [4].

Sample	Type	Particle Size
Allende	CV3	0-75µm
Allende	CV3	250-425µm
DaG 083	CO3	0-75µm
DaG 083	CO3	250-425µm
NWA 502	CO3.5	0-75µm
NWA 502	CO3.5	250-425µm
NWA 5515	CK4	0-75µm
NWA 5515	CK4	250-425µm

Table 1: Description of the samples measured using the current setup.

-lating the effect of solar radiation on the surface of an airless body. Radiation emitted from the sample is reflected into an FTIR spectrometer by a cooled collecting mirror positioned above the sample.

To create the correct temperature gradient, the temperature of the sample at the bottom of the sample cup needs to match the expected temperature at that depth on Bennu. Given that this is unknown, spectra are taken with several different sample cup temperatures, typically 283K (i.e. unheated), 333K and 353K. The lamp output is then altered until the sample's surface brightness temperature is 350K, as on Bennu [1,5].

'Earth-like' measurements are also made by heating the sample cup to 353K in 1000mbar of nitrogen gas (N_2), to allow comparison between SAE spectra and those made in isothermal conditions. Table 1 shows the samples measured under SAE and N_2 conditions. The initial sample suite contained CV, CO and CM chondrites as these provided a range of possible compositions. However, during testing the Murchison (CM) sample released a volatile component when heated; the composition of which is currently being investigated. To prevent damage to the sample or the chamber, the CM sample was not measured in this study.

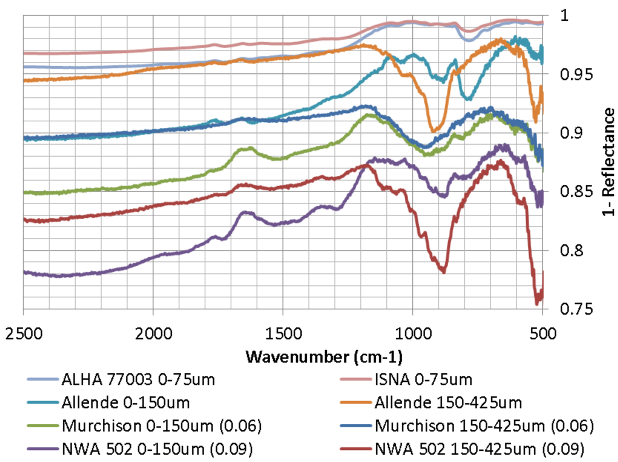

Figure 2: Diffuse reflectance spectra of a selection of meteorites from the ASTER spectral library (ALHA and Isna 0-75µm [6]) as well as some measured during this study. Spectra have been offset for clarity by the value given in the legend.

Results: Diffuse reflectance spectra of a selection of meteorite samples are shown in Figure 2. From the results of previous work investigating thermal gradients in lunar analogues and Apollo samples, variations in spectra between N_2 and SAE measurements would be expected for the 0-75µm sized samples [e.g. 3,4]. For the samples measured to date, spectral differences between N_2 and SAE are minimal, with absorption bands and emission peaks observed at the same wavenumbers. The exception to this was DaG 083 0-75µm (Figure 3), which showed some change near the Christiansen Feature (CF), an emissivity maximum around 1250cm^{-1}, as the CF appears to shift to a lower wavenumber under SAE conditions, from approximately 1150cm^{-1} to 1190cm^{-1} (~8.7µm to 8.3µm). This shift is similar to the CF shifts observed in lunar analogues and Apollo samples measured under simulated lunar conditions.

Conclusions: For the carbonaceous chondrite meteorites analysed in this study, SAE conditions do not alter emissivity spectra to the degree observed in lunar soils and their analogues. This is likely due to the albedo and thermal conductivity of the meteorite samples, but these variables will need to be explored further in future studies.

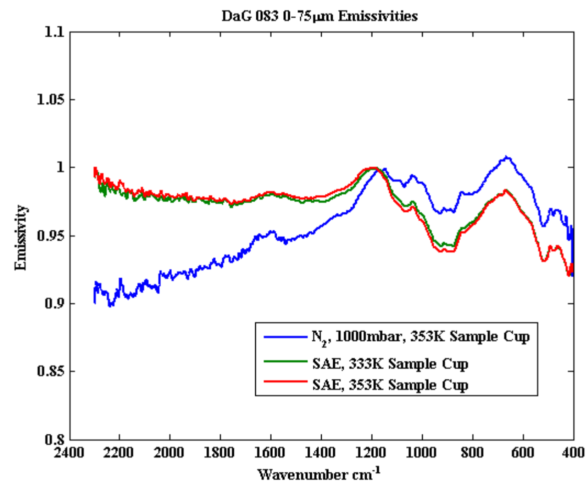

Figure 3: Nitrogen and SAE emissivity spectra of DaG 083 0-75µm. The temperature in the legend indicates the sample cup temperature for each measurement.

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