THERMAL EMISSION SPECTROSCOPY OF ORDINARY CHONDRITES AT SIMULATED ASTEROID CONDITIONS WITH IMPLICATIONS FOR ASTEROID THERMOPHYSICAL AND COMPOSITIONAL INTERPRETATIONS. M. S. Bramble1 and R. E. Milliken1, 2Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, USA (michael_bramble@brown.edu).

Introduction: Thermal infrared spectroscopic measurements record not only compositional information about the properties of a target but also about the environmental conditions in which the measurement was acquired. Spectral variations resulting from different environmental conditions are less apparent when measurements are acquired at terrestrial or martian conditions [1–4]. However, spectral variations resulting from the cold and vacuum environment of airless planetary surfaces can be significant and can greatly influence interpretations of physical and chemical properties of those surfaces when using emissivity spectra [e.g., 1, 2, 4–7]. The absence of interstitial gasses at vacuum conditions can lead to the formation of intense near-surface thermal gradients in particulate (regolith) materials that result in changes in emission spectral features [e.g., 1, 2, 4–7]. Once such category of airless planetary surfaces that is of great interest to the asteroid and planetary defense communities is S-type asteroids, a group that represents the most abundant objects in the inner main belt and near-Earth object populations [e.g., 8]. Through their paring with the ordinary chondrite (OC) meteorites, we can measure the latter under controlled asteroid-like conditions to probe how thermal and emissivity properties respond due to a cold and vacuum environment to better understand the compositional and thermophysical properties of OC parent bodies and other S-type objects.

We report here on a broad suite of environmental chamber measurements focused on anhydrous silicates, mixtures of silicates and metal, and ordinary chondrite samples, and we discuss how their thermal/emissivity properties vary between ambient and simulated asteroid environment (SAE) conditions. Understanding how thermal emission characteristics of relevant planetary materials are altered in an airless environment is important to advance our quantification of thermal re-radiation forces such as the Yarkovsky effect, and an improved understanding of the thermal properties of OCs under asteroid-like conditions can lead to better estimates of the forces that govern how objects move from the main belt to the near-Earth population.

Methods: A suite of OCs spanning the three groups (H, L, and LL) and at each thermally metamorphosed petrologic type (4–6) was acquired through the US Antarctic Meteorite Collection, and single mineral phases and mixtures chosen to mimic OC mineralogy were also measured for comparison. These samples were crushed, ground, and sieved into <25, 25–125, and 125–250 µm aliquots and thermal emission measurements were acquired at (1) ambient and (2) cold, vacuum conditions. Measurements were made with the Asteroid and Lunar Environment Chamber (ALEC) at Brown University [9]. The SAE conditions were produced in a vacuum (<<10–4 mbar) with samples heated from below in sample cups and irradiated from above by a 200 W quartz-halogen lamp. A liquid N2 cooled, rotary mounting platform holds heated sample holders each surrounded by an aluminum radiation shield that forms an enclosed ~85 K environment. Spectra were collected over a wavelength range of 2.5–25 µm (400–4000 cm−1) through an emission port on a Thermo Nexus 870 FTIR spectrometer equipped with a DTGS detector. FTIR emission spectra were reduced to radiance, emissivity, and brightness temperature spectra using the absolute radiometry method developed for the ALEC system [9].

Results: Our emissivity spectra of OCs and mineral analogs display the expected spectral alterations due to the transition to SAE conditions based on results of previous studies of silicates in this environment [4–7, 10, 11]. Notably, the spectral contrast between the Christiansen feature (CF, an emissivity maximum) and the reststrahlen bands (RB) increases, and the CF position shifts towards higher wavenumbers for the SAE (Fig.1).

Using both the spectral contrast between the CF and RBs and variations in brightness temperature as a function of wavenumber, we confirm that the thermal gradients are less intense in both our analog OC mixtures and the suite of OCs compared with single mineral phases, and that gradients become less intense with increasing metal content (LL to H). Additionally, the shift in CF position is less intense in the meteorites and mixtures than the single phases. This confirms a hypothesis by
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Figure 2: (a) Band depths of the ~945 cm⁻¹ spectral feature from a suite of mineral mixtures with a particle size of 125–250 μm that mimic the three OC groups. (b) Band depths of a ~880 cm⁻¹ feature in a suite of type 4 OCs spanning the H, L, LL groups (LaPaz Ice Field 10001, Wisconsin Range 91603, Grosvenor Mountains 95552). All spectra were collected with heated cup temperature of 400 K and either at ambient (AMB) or simulated asteroid environment (SAE) conditions.

Figure 1: (a) Plot of integrated radience across the thermal IR region as a function of temperature using emissivity data from an LL analog mineral mixture compared to the LL5 LaPaz Ice Field 10009 sample (both with a particle size of ~25 μm). These integrated radience curves are compared to a blackbody and 75% greybody. All spectra were collected with heated cup temperature of 400 K and either at ambient (AMB) or simulated asteroid environment (SAE) conditions. (b) Example subsolar temperatures recalculated using the data as in (a) as a function of heliocentric distance.