VERIFICATION AND CHARACTERIZATION OF GEOLOGICAL SAMPLES ON BOARD THE MANITOBASAT-1 3U CUBESAT. N. N. Turenne1*, E. A. Cloutis1, D. M. Applin1, P. Mann1, S. A. Connell1, M. Ramirez1, C. Kiddel1, A. E. Parkinson1, K. Kubanek1, J.C. Kuik1, E. Stanish1, P. Ferguson2, M. Driedger2, J. Campos3, V. Platero2, and H. Umar-Lawal2; 1Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, R3B 2E9, Canada; 2Faculty of Engineering, University of Manitoba, 66 Chancellors Cir, Winnipeg, Manitoba, R3T 5V6, Canada; 3nat.turenne@hotmail.com.

Introduction: ManitobaSat-1 is a 3U-sized CubeSat that is being designed and assembled by the engineering team at the University of Manitoba’s STARLab [1]. The sample payload component is being assembled at the University of Winnipeg, and will consist of geological samples with the goal of studying the effects of space weathering on the surfaces of airless bodies, such as the Moon and asteroids, and is the first orbital experiment of its kind. It will also help inform the results of laboratory studies of space weathering.

The geological samples will be exposed to solar wind irradiation, cosmic rays, and micrometeorite bombardment [2]. The samples will also be exposed to vacuum desiccation and thermal cycling, as the satellite moves in and out of Earth’s shadow. Space weathering causes variations in the optical properties of solar system bodies as a function of the surface composition and location in the solar system [2]. Changes in spectral slope associated with color changes are proven to occur from weathering and changes in physical properties of the samples [3]. This experiment of understanding how geological samples are affected by space weathering enhances our lab knowledge and exploration missions on asteroid composition including OSIRIS-Rex asteroid sample return mission [4].

After launch and in orbit, the CubeSat will acquire data of the geological samples to indicate any spectral changes exhibited in low-Earth orbit. The geological samples will be observed using two cameras looking for changes in their reflectance within the visible spectrum over the mission’s ~1 year lifetime no less than once per week.

Here, we report testing of the payload samples to analyze their spectral and physical properties before launch and ensure their structural stability before and while in space.

Methods: A total of 39 terrestrial and meteorite rocks were selected to be payload sample candidates due to their relevance to lunar and asteroid surfaces as shown by [5] at this conference. From these the minimum requirement on board the CubeSat is 10 pellets and a maximum of 24 pellets.

The sample plate will include three Lucideon and Avian standards that are also being used as Mastcam-Z calibration standards. These include diffuse Aluwhite98, grey33, and cyan. In addition to the 6061-T6 aluminum that makes up the payload sample plate will be used as a spectral standard.

This study is replicating the calibration standard fabrication methods used for the SuperCam Mars2020 instrument. The CubeSat samples were powdered to <45 µm before being sent to CIRIMAT, where they were sintered under vacuum with heat and applied pressure to form a solid pellet (Fig 1). Each sample was heated to just below its melting temperature. Additional in-house pellets were prepared with <45 µm powders and pressed into 1” pellets at 35 tonnes applied force.

Powdered, in-house produced pellets, and sintered pellets were analyzed with UV-VIS-NIR reflectance using a LabSpec 4 Hi-Res spectrometer (ASD) from 350 to 2500 nm. In-house pellets and sintered pellets were analyzed using a BWTek i-Raman-532-S from 150-4000 Å cm⁻¹ and X-ray diffraction was used to characterize the powders and sintered pellets using a Bruker D8 Advance diffractometer. Sample verification was used to identify any spectral or structural differences caused by any unwanted alterations after the pellet sintering process. X-Ray Fluorescence (XRF) was used to determine all sample compositions before flight.

![Figure 1: Sintered olivine (OLV003) pellets with graphite coating (left), sintered olivine (OLV003) pellet with graphite coating removed (right). Each pellet is ~10 mm in diameter.](image)

The graphite coating surrounding the pellets from the sintering process was removed from all sides and the pellets were carefully inspected under a microscope to ensure complete graphite removal and to remove any loose materials (Fig. 1).
Each pellet was friction tested using the same 6061-T6 aluminum as the payload’s sample plate. Friction tests results were used to determine the static coefficient of friction between the samples and the 6061-T6 aluminum. The friction results are also used to determine the clamping force for the samples required for launch and operations.

Vibration testing is ongoing at the Magellan Aerospace lab to ensure that the pellets are structurally robust to survive launch and operations. The pellets are being subjected to random vibrations in 3 axis (X, Y and, Z) performed at 9.47 g’s root mean squared for 60 second durations (Table 1). Sample inspections are done before and after testing to ensure no damage to each pellet.

<table>
<thead>
<tr>
<th>Hard-Mount Test Profile</th>
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<tr>
<td><strong>Frequency (Hz)</strong></td>
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Table 1: Nanoracks Random vibration test profile for hard mounts [6].

Additionally TVAC testing will be performed.

Results: 14 of the pellets did not make it past the sintering process likely due to their non-homogeneous nature (i.e., meteorites and rocks), or failed qualification. The samples that came back to C-TAPE under the threshold of diameter or height did not pass qualifications and will not be included in further testing.

Raman: The Raman spectra for multiple geological samples shows that the sintered pellets have much less fluorescence then the in-house pellets (Fig. 4). This could potentially be due to the removal of fluorescing contaminants such as finger oils during the sintering process. The sintered pellets of UCF/DSI exhibit olivine peaks [7] not seen in the in-house pellets due to the increased fluorescence.

Vibration testing: To date, vibration testing has been successful for three sample types and four pellets, including olivine (OLV003), a Lunar mare simulant (BAS600), and pyroxene (PYX023). No cracks, loose materials or other damage was observed after the testing, deeming them safe for space.

Discussion and conclusions: In general, the Raman, reflectance, and XRD data indicate that the sample compositions are unaltered from sintering.

Physical and structural testing of the geological samples is ongoing and will identify the robustness of the pellets for launch and operations. Once this section is completed the pellets that passed will be selected for the payload. From the results to date we still have ample room for failures to achieve the minimum requirements for launch and data collection.

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