ESTABLISHING TECHNIQUES FOR THE SEARCH FOR LIFE THROUGH THE ANALYSIS OF THROMBOLITES USING MARS 2020 ROVER-LIKE INSTRUMENTATION. A. E. Parkinson[1*], E. A. Cloutis[1], D. M. Applin[1], N. N. Turenne[1], J. C. Kuik[1], S. A. Connell[1] and K. Kubanek[1]. [1]Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, MB, Canada. *parkin19@hotmail.com

Introduction: Thrombolites can be considered a sub-type of stromatolites originally labeled as non-laminated structures [1]. Thrombolites differ from traditional stromatolites by having localized clustering rather than layering, which creates numerous clots randomly scattered throughout a specimen [1, 2]. These structures are usually preserved with dolomite/calcite/chert matrices.

Schreiber Beach, Thunder Bay, ON is the type locality of the well-studied Gunflint chert. Thrombolites in these materials are of astrobiological interest for two main reasons; the unique forms of life that had developed, and the old age of the matrix materials [3]. The matrix of these materials are dominated by chert and carbonates [1]; the chert matrix has been dated to be roughly 1.9 billion years old [3]. Previous studies have found the preservation of uniquely adapted life at Schreiber Beach [4, 5, 6]; for example, adaptation such as iron-metabolizing organisms [3], being able to live in soil, ammonia-rich, and anoxic environments [7].

Laminated carbonate and chert structures have been detected with the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) and by the Mars Exploration Rovers (MER) Spirit and Opportunity [2, 8]. These observations make for the Schreiber Beach thrombolites to be a good analogue for Mars exploration focusing on stromatolites and thrombolite detection.

Traditional stromatolites have clear indicators of life preserved within the layers, while the thrombolites clotted matrix makes it more difficult to visually identify where the microstructures might be. Extending to longer wavelengths can detect features that are not seen with optical imaging. When discussing the ability of a rover detecting thrombolites we focused on instruments deployed on previous rovers, Curiosity, the upcoming NASA 2020 Mars rover and the Exo Mars 2020 rover.

Methods: Six samples were collected in a transect across the Gunflint Iron formation at Schreiber Beach. Three samples, ONT400, ONT401, and ONT404, were cut and polished to visually identify possible organic microstructures. The other three, ONT402, ONT403 and ONT405, were left unaltered from their collection state to assess the influence of sample preparation.

RGB imaging: A dissection microscope at 45x magnification was used to visually identify areas of interest. A tungsten light source was used and samples were wetted to help in identifying areas of interest. These areas would range between different mineralogy to possible organic structures. RGB images, with a Bayer-filtered sensor, were taken to compare visual identification to spectrally detected areas of interest (Figure 1).

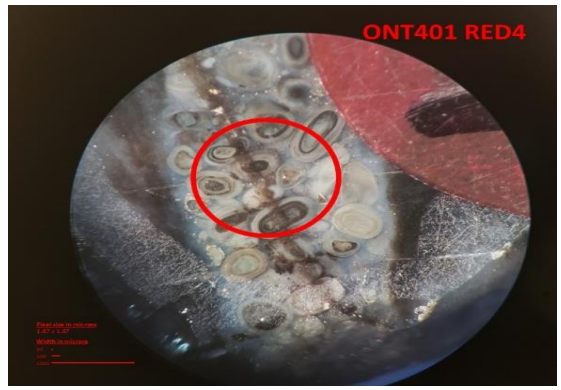

Figure 1. Image taken of ONT401 under a microscope depicting possible organic microstructures seen throughout the Schreiber Beach thrombolites. The red circle indicates the IFOV for VNIR reflectance measurements.

Raman: A 532 nm BWTek iRaman was used to simulate the SuperCam and RLS found on upcoming Mars rover missions. The collection spot size is ~80 µm.

Visible and near-infrared (VNIR) reflectance: Reflectance spectra (350-2500 nm) were acquired with a LabSpec 4 Hi-Res (ASD). The ASD was used to simulate the capabilities of the SuperCam, and Ma_MISS instruments found on the upcoming Mars rover missions. Slab samples were used to collect spectra on a spot size of ~1.75 mm (Figure 1).

X-ray diffraction (XRD): was used for in-lab analysis to simulate the CheMin instrument found on the Curiosity rover. XRD was used for the purpose of understanding the general mineralogy of the samples.

Results: *Raman:* Raman excelled at detecting carbon signatures such as the graphitic G-band (~1600 cm^{-1}) and D-band (~1350 cm^{-1}) as seen in Figure 2. Raman also excelled at detecting the major and minor mineralogy; identifying quartz and calcite bands as the strongest features. Quartz is indicated by the 210, 405, 460, 700, and 810 cm^{-1} peaks (Figure 2), with calcite features seen at 280 and 1085 cm^{-1} (Figure 2). Minor mineralogy seen within the thrombolite samples is a sulfide with a 355 cm^{-1} peak seen in a majority of the samples. Hematite can be seen in ONT405 at 500 cm^{-1} and at 610 cm^{-1}. Hematite may also contribute to the breadth of the D-band.

VNIR reflectance: The spectra displays clear calcite, H_2O/OH, and Fe features (Figure 3). Wa-

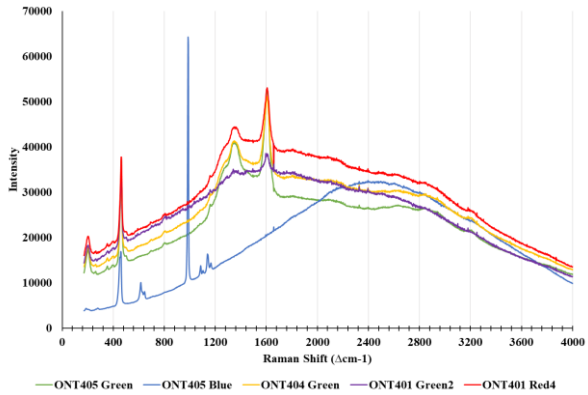

Figure 2. Raman spectra of slab thrombolite samples collected at Schreiber Beach analyzed with unaltered surface (ONT405) and cut/polished surface (ONT401, ONT404) showing the detection of graphitic carbon and bulk mineralogy.

ter/hydroxyl features at 1400 and 1900 nm are seen in all samples (Figure 3). ONT401 displayed broad iron features that indicate Fe^{2+} and Fe^{3+} at ~700 nm and ~900 nm and an oxidized iron band at ~1200 nm appearing as a broad dip (Figure 3). Broad bands at ~1050 and ~1250 nm in Figure 3 indicate Fe^{2+} crystal-field splitting in Fe-bearing carbonates (e.g., dolomite, siderite) seen in samples ONT400 and ONT401 (Figure 3). A single relatively broad feature at ~2200 nm can be indicative of hydrated silica, seen in ONT400 (Figure 3). The most distinctive spectral features seen in Figure 3 are those that indicate the presence of calcite: a shoulder at ~2167nm on the strong band at ~2333 nm (Figure 3). All calcite features can be seen within ONT402 and the main feature at ~2333 nm is observable in ONT401 (Figure 3).

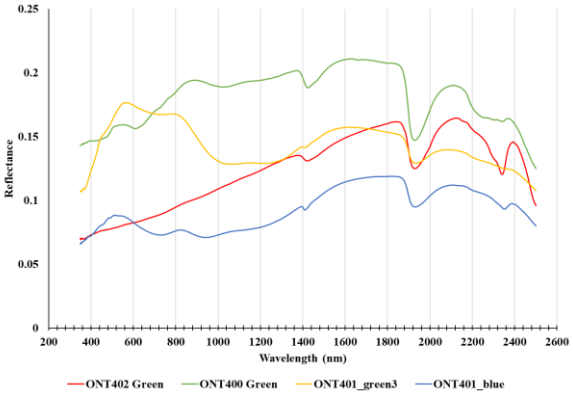

Figure 1. Reflectance spectra of slab thrombolites collected from Schreiber Beach with unaltered (ONT402) and cut/polished (ONT400, ONT401) surface.

XRD: This functioned to establish the general mineralogy of the thrombolites. For ONT401 and ONT404 quartz and calcite were detected. Within ONT400 quartz and calcite with smaller concentrations of hematite, pyrite, sylvite, halite, and pyrrhotite were detected. ONT405 had quartz, calcite, and in smaller concentrations of sylvite, halite and marcasite. This is all consistent with previous studies of the Gunflint chert.

Discussion: As previously established, Raman spectroscopy is useful in the search for preserved evidence of life because of its ability to detect sp^2 carbon in small concentrations, as well as the bulk mineralogy used to identify thrombolite structures. By conducting Raman spectroscopy on the Thunder Bay thrombolites we show that should similar samples be found on the martian surface, instruments on the upcoming rover missions could detect graphitic carbon signals (Figure 2).

VNIR reflectance detected and characterized the major matrix mineralogy; calcite, silica, and Fe-oxides. The detection of multiple Fe oxidation states are of interest because of life's reliance and interaction with iron can be a sign of past or present life [3, 9].

XRD identified and characterized bulk major and minor mineralogy, strongly complemented the analysis of VNIR reflectance and Raman spectra. XRD also provided trace mineralogy that Raman and ASD did not, such as the presence of salts (halite and sylvite), which are known to occur within these thrombolites due to the salty aquatic environment in which they formed [3, 5].

Datasets from these instruments can be used to complement each other because each had its individual strength in the identification and detection of mineralogy and biosignatures that would indicate signs of life. VNIR reflectance and XRD would be great starts to look for general past environments that would be able to form thrombolites and Raman spectroscopy would then be used in the detection of organic signatures.

Further Analysis: Further analysis of Mars rover-like instruments such as Laser Induced Breakdown Spectroscopy, hyperspectral imaging, SEM-EDS mapping at the spatial resolution of the PIXL instrument, and FTIR reflectance are being conducted and results will be presented at the conference.

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