LITHOLOGIC MAPPING OF IMPACTITES FROM THE HAUGHTON STRUCTURE, CANADA, USING IMAGING SPECTROSCOPY. R. N. Greenberger[1], B. L. Ehlmann[1,2], G. R. Osinski[3,4], L. L. Tornabene[3,5], R. O. Green[1], J. F. Mustard[6], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109 (Rebecca.N.Greenberger@jpl.nasa.gov), [2]Div. of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, [3]Dept. of Earth Sciences & Centre for Planetary Science and Exploration, University of Western Ontario, London, ON, N6A 5B7, Canada, [4]Dept. Physics & Astronomy, University of Western Ontario, London, ON, N6A 5B7, Canada, [5]SETI Institute, Mountain View, CA 94043, USA, [6]Dept. of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI, 02912.

Introduction: Meteorite impacts are one of the most common geological processes in the solar system, and the resulting impactites provide insights into the pre-impact lithologies and impact processes. The ~23 km diameter Haughton impact structure, Devon Island, Canada (75.37°N, 89.68°W), formed 23.5 ± 2.0 Ma in ~1880 m of Lower Paleozoic sedimentary rocks overlying Precambrian crystalline basement [1, 2]. The lithologies at Haughton have been mapped through traditional geologic field study [1] and multispectral remote sensing [3]. In this abstract, we use laboratory imaging spectroscopy to map lithologies within individual samples to better understand the samples, their compositional and spectral diversity, and as preliminary work for our 2016 imaging spectroscopy field campaign.

Materials and methods: Samples were collected at Haughton during the 2013 field season and imaged in the laboratory at California Institute of Technology with co-boresighted visible-near infrared (VNIR) and short-wave infrared (SWIR) pushbroom imaging spectrometers. The VNIR sensor covers wavelengths 0.4-1.0 µm with 1600 spatial pixels, 371 spectral pixels, and 5 nm spectral resolution. The SWIR sensor covers 1.0-2.6 µm with 640 spatial pixels, 283 spectral bands, and 6 nm spectral resolution. Spatial resolution varies with distance between the sample and imager but for these measurements was ~125 µm/pixel VNIR and ~375 µm/pixel SWIR. Samples were scanned by rotating the imaging spectrometer on a motor-controlled stage. Dark current was subtracted and calibration to reflectance was done using Spectralon®. Samples were analyzed by calculating spectral parameters [e.g., 4] and using combinations of spectral parameters to map minerals.

Results: Minerals identified thus far with spectroscopy include calcite, dolomite, hydrated silica, gypsum, and garnet. These detections are consistent with those previously identified at this impact structure [e.g., 1, 3]. Here, we map these phases spatially and look at the relationships between them.

Fig. 1a-b shows a sample from an outcrop of clast-rich impact melt rock. Here, clasts with spectral signatures of calcite, dolomite, hydrated silica, and gypsum are mapped. The hydrated silica signature is often identified in clasts of gneiss and/or sandstone. Between the clasts, the matrix is characterized spectrally by two absorption features at 2.21 and 2.32 µm (Fig. 1g), suggesting a mixture of a hydrated silica-bearing phase and a carbonate [5-6]. Indeed, Osinski et al. [7] found that the matrix of impact melt rocks at Haughton contains quenched calcite and a volatile-bearing (likely hydrated) silicate-rich glass mixed on a finer spatial scale than the resolution of our measurements.

Other samples contain fewer of the lithologies present at Haughton but are equally interesting. The sample shown in Fig. 1c-d is, visually, a monomict breccia. Imaging spectroscopy identifies the sample as dolomite, though more variability is present than is visible by eye. There are minor variations in the Mg/Ca content of the carbonate, shifting the resulting absorption feature between 2.31 and 2.33 µm [6]. In addition, the depth of the H-O-H combination band at 1.9 µm is related to water content in the sample and varies spatially.

Gypsum is identified in many samples (e.g., Fig. 1e-f, along with calcite). In some samples, including those collected from uplifted Bay Fiord Formation outcrops, there is obvious gypsum, while other samples contain small clasts or coatings not visually identified.

Conclusions and future work: Calcite and dolomite spectra derive from limestone and dolostone in the target rocks. The hydrated silica signature is characteristic of sandstone and chert (sedimentary) as well as gneiss in the Precambrian basement. Garnet is only seen in gneisses. All of the minerals identified here are found in pre-impact materials [1], though they have been shocked and displaced from their original locations and now occur as clasts in impact melt rock or in uplift. We suspect that the ~2.21 µm feature due to Si-OH, often seen in amorphous or opaline silica, may be affected by shock metamorphism of water-bearing quartz-rich lithologies. The intimate mixture of quenched silica and calcite within melt-bearing rocks has a distinct spectral signature and is clearly a product of the impact process. There is localized hydrothermal mineralization around the structure that mobilized and precipitated some of the same minerals identified here as well as others [8], and these can be mapped with this technique, using petrographic contexts to distinguish pre- and post-impact formation.

Imaging spectroscopy is a powerful technique to map lithologies present in heterogeneous samples such as these. In the coming months, we will image more samples in the lab and improve mineral mapping techniques to better characterize our current sample set and prepare for future measurements.

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References: [1] Osinski G. R. et al. (2005) *MAPS*, *40*, 1579-1776. [2] Young K. E. et al. (2013) *GRL*, *40*, 3836-3840. [3] Tornabene L. L. et al. (2005) *MAPS*, *40*, 1835-1838. [4] Pelkey S. M. et al. (2007) *JGR*, *112*, E08S14. [5] Aines R. D. and G. R. Rossman (1984) *JGR 89*, 4059-4071. [6] Gaffey S. J. (1987) *JGR*, *92*, 1429-1440. [7] Osinski G. R. and J. G. Spray (2001) *EPSL*, *194*, 17-29. [8] Osinski G. R. et al. (2005) *MAPS*, *40*, 1859-1877.

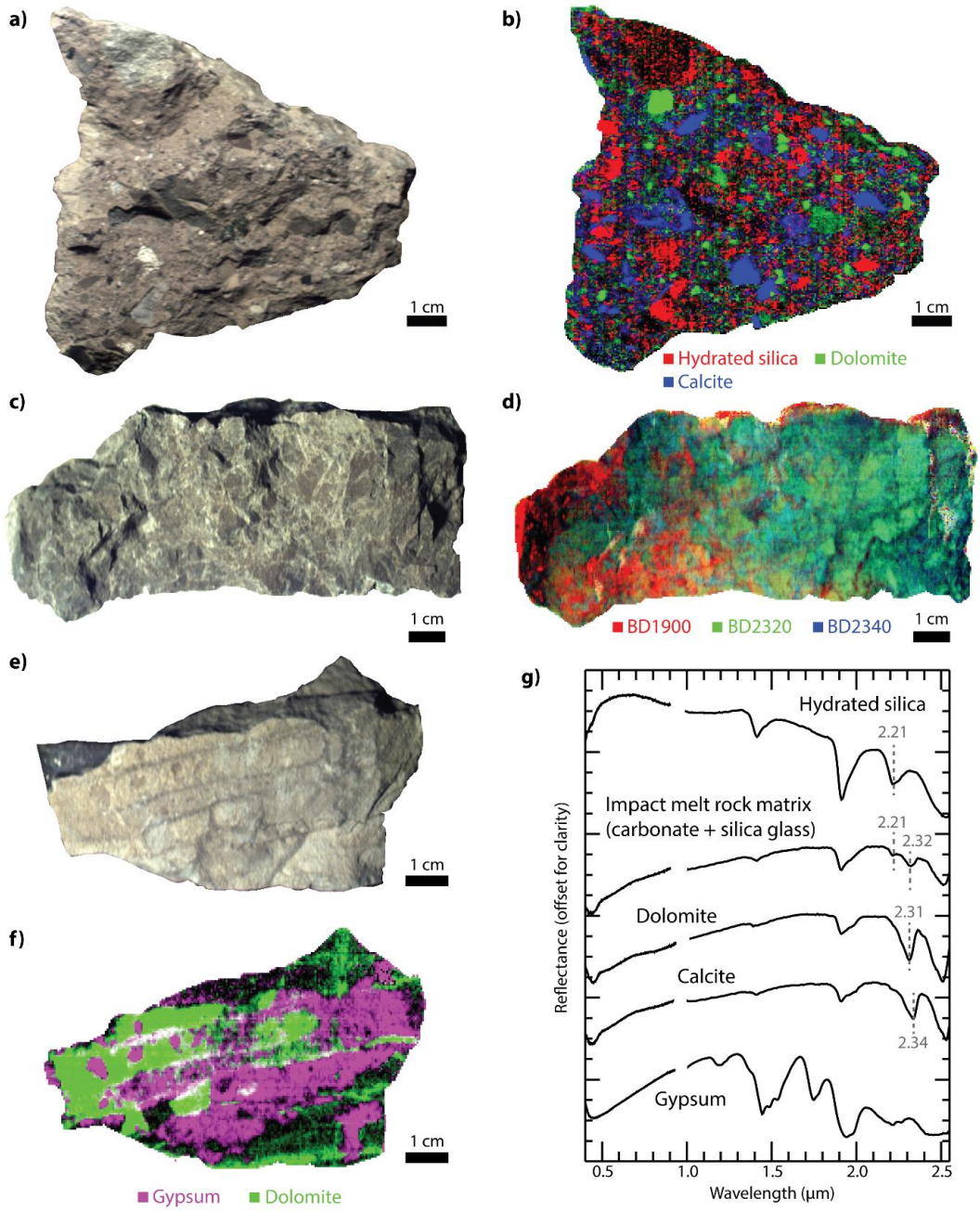

Fig. 1. Images of samples from the Haughton impact structure. a) Approximate true color composite of clast-rich impact melt rock RG-HMP-13-27 and b) corresponding mineral indicator map. c) Approximate true color image of monomict breccia RG-HMP-13-28 and d) spectral parameter map (red has more water, green indicates more Mg-rich carbonate while blue is more Ca-rich). e) Approximate true color image of calcite and gypsum-bearing clast RG-HMP-13-32 and f) mineral indicators. g) Example spectra of different lithologies. Spectra of the melt rock matrix, dolomite, and calcite are from the sample shown in A. Other spectra are from samples not shown in this figure.