Lichen biodiversity and ecology at two Mars Analog Sites: the Flashline Mars Arctic Research Station (Nunavut, Canada) and the Mars Desert Research Station (Utah, USA)

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Lichen Biodiversity Studies to Characterize Planetary Analogs

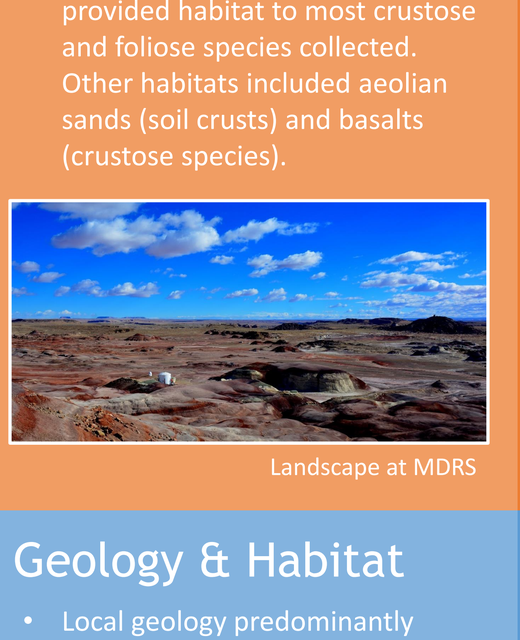
The Flashline Mars Arctic Research Station (FMARS) at Haughton Crater, Devon Island, Nunavut, and its counterpart, the Mars Desert Research Station (MDRS) in southern Utah, are simulated Mars outposts situated at two well-known Martian planetary analogs: environments that are geologically and environmental similar to the solar system's fourth planet. Owned and operated by the Mars Society, these stations host researchers learning how to live and work on Mars. Crews conduct research programs on everything from testing new rovers to isolating local microbes; these Astrobiology simulations are a particularly important dress-rehearsal in the search for potential life on Mars. These studies rely on comprehensive knowledge of the local biota, therefore traditional natural history surveys are an important precursor to these simulated missions.

Lichens, in particular, are ecologically important in the extreme environments selected as planetary exploration analogs due to their resistance to UV radiation and desiccation - some species are even able to survive exposure to space (Sancho et al. 2007). At MDRS and FMARS these species grow in rock and soil, and exchanging photobionts with endolithic colonies of algae and biological soil crusts (Sokoloff et al. 2016). Characterizing these lichens within the operational areas of station crews would be useful to biology fieldwork at these sites, and the search for these organisms is analogous to the future manned search for biomarkers on Mars.

As a part of the Mars 160 Twin Study program conducted by the Mars Society in 2016-2017 our team conducted a lichen biodiversity and geological substrate survey of these two stations during two simulated Martian missions, resulting in 146 new lichen collections deposited at the National Herbarium of Canada (CANL) at the Canadian Museum of Nature, including the first known lichen specimens from Haughton Crater, on Devon Island, Nunavut.

Crew Biologist Anushree Srivastava collects lichen samples while wearing a simulated spacesuit in the deserts of southeast Utah, USA.

The Arctic crew of the Mars 160 Mission arrives at the Flashline Mars Arctic Research Station at Haughton Crater, Devon Island, Nunavut, Canada.



MDRS September 23 – December 13, 2016 **117 collections**

MDRS near San Rafael Swell, Utah, 38°24'23.12"N, 110°47'30.94"W

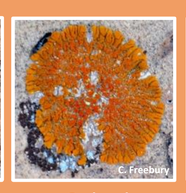
Collection sites for 2016 field campaign (Google)

Lichens were collected by Anushree Srivastava and Yusuke Murakami during 16 extravehicular activities (EVAs) from the "hab". Notes on the geological substrate were compiled by Jon Clarke. Previous work documented 13 lichen species from the MDRS area and 61 species from Wayne County (Sokoloff et al. 2016) and 23 terricolous species from the nearby San Rafael Swell (Rajvanshi et al. 1998).

Lichens

- Determination of these samples are currently underway by Paul Sokoloff, 35/117 samples determined (29%).
- Species commonly collected include:
  - *Acarospora strigara*
  - *Caloplaca trachyphyllla*
  - *Xanthoparmelia plittii*
- Majority of specimens collected were crustose (65%).
- *Acarospora schleicheri* is newly reported for the MDRS area.

Acarospora strigata



Caloplaca trachyphylla

Candelariella rosulans

Geology & Habitat

- Local geology predominantly sandstone from Jurassic Morrison and Cretaceous Dakota Formations. These conglomerates provided habitat to most crustose and foliose species collected. Other habitats included aeolian sands (soil crusts) and basalts (crustose species).

Landscape at MDRS

FMARS July 17 – August 13, 2017 **27 collections**

FMARS near Haughton Crater, NU, 75°25'52.72"N, 89°49'24.28"W

Collection sites for 2016 field campaign (Google)

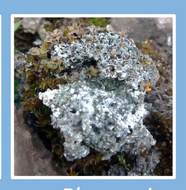
Lichens were collected by Anushree Srivastava during 6 EVAs. Notes on the geological substrate were compiled by Jon Clarke and Paul Knightly. This is the first survey of lichens for the Haughton Crater and the western half of Devon Island. Previous studies have found 182 lichen species from the locally-rich Truelove Lowlands on the northeastern coast of Devon Island (Barrett and Thomsen 1975).

Lichens

- Determination of these samples are currently underway by Troy McMullin, 6/27 samples determined (22%).
- Species commonly collected include:
  - *Xanthoria elegans*
  - *Lecanora marginata*
- Majority of specimens collected were crustose (88%).
- Due to a shortened season, future work should find additional species.

Lecanora marginata

Xanthoria elegans



Physconia muscigena

Geology & Habitat

- Local geology predominantly Paleozoic limestone and impact breccias of the Haughton impact crater. Most lichen species were collected on siltstone, with few other species collected on breccia, quartz, and epiphytic on moss (which are not abundant in the vicinity of MDRS).

Landscape at FMARS

Summary

Identification of the lichen specimens is ongoing, but, interestingly, only one species has been found in common between the two sites so far – *Xanthoria elegans* - despite some climatic similarities (i.e. moisture, substrate, soil formation), and the discovery of a species characteristic of the American southwest (*Acarospora schleicheri*) on Ellesmere Island in 2017 (McMullin 2018). The only shared family identified so far is the cosmopolitan Teloschistaceae, which includes *Xanthoria elegans* and *Caloplaca trachyphylla*. The underlying substrate of the two analog stations (sandstone vs. limestone) may account for differences in species assemblage composition.

Human Factors also played a role in lichen sampling. The biology team on MA160 were briefed on lichen prospecting and collected, but were not lichenologists. The most commonly collected species at each site were conspicuous macrolichens with coloration that stood out on the local landscape (i.e. white *Acarospora strigata* in Utah and orange *Xanthoria elegans* in Nunavut). As well, crew on EVA often have to balance multiple competing priorities in addition to any science goals, and EVAs are time-limited to simulate working on the irradiated surface of Mars. With additional training and time on the ground, the same crew would undoubtedly collect additional, overlooked species. The ability of the crew to learn-by-doing is critical to studies in crewed spaceflight, where non-specialists often must complete science-return for an Earthside team. Continued lichen sampling at both stations will aid human-factors work in field astrobiology training, and will add new biodiversity records for these fascinating extreme environments.

Extravehicular lichen surveying by Anushree and Jon on Devon Island (top) and by Yusuke in Utah (left).
Mars 160 Mission Patch (right).

References

- Barrett, P., & Thomson, J. (1975). Lichens from a High Arctic Coastal Lowland, Devon Island, N.W.T. The Bryologist, 78(2), 160-167. doi:10.2307/3242046
- McMullin, R.T. (2018). New and interesting lichens and allied fungi from British Columbia, Nova Scotia, Nunavut, Ontario, Prince Edward Island, and Quebec, Canada. Opuscula Philolichenum, 17: 275-292. 2018.
- Rajvanshi V., St. Clair L., Webb B., & Newberry C. (1998). The terricolous lichen flora of the San Rafael Swell, Emery County, Utah, U.S.A. In: Glenn M, Harri R, Dirig R, Cole M (Eds) Lichenographia Thomsoniana: North American Lichenology in Honor of John W. Thomson. Mycotaxon, Ithaca, NY, 399-406 pp.
- Sancho, L.G., De la Torre, R., Horneck, G., Ascaso, C., de los Rios, A., Pintado, A., Wierzchos, J. & Schuster, M. (2007). Lichens survive in space: results from the 2005 LICHENS experiment. Astrobiology, 7(3), 443-454
- Sokoloff P., Freebury C., Hamilton P., & Saarela J. (2016). The "Martian" flora: new collections of vascular plants, lichens, fungi, algae, and cyanobacteria from the Mars Desert Research Station, Utah. Biodiversity Data Journal 4: e8176. https://doi.org/10.3897/BDJ.4.e8176