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Title: Field Exploration and Life Detection Sampling through Planetary Analogue Sampling (FELDSPAR).

Abstract:
Exploration missions to Mars rely on rovers to perform analyses over small sampling areas; however, landing sites for these missions are selected based on large-scale, low-resolution remote data. The use of Earth analogue environments to estimate the multi-scale spatial distributions of key signatures of habitability can help ensure mission science goals are met. A main goal of FELDSPAR is to conduct field operations analogous to Mars sample return in its science, operations, and technology from landing site selection, to in-field sampling location selection, remote or stand-off analysis, in situ analysis, and home laboratory analysis.

Lava fields and volcanic regions are relevant analogues to Martian landscapes due to desiccation, low nutrient availability, and temperature extremes. Operationally, many Icelandic lava fields are remote enough to require that field expeditions address several sampling constraints that are experienced in robotic exploration, including in situ and sample return missions. The Fimmvörðuháls lava field was formed by a basaltic effusive eruption associated with the 2010 Eyjafjallajökull eruption. Mælifellssandur is a recently deglaciated plain to the north of the Myrdalsjökull glacier. Holuhraun was formed by a 2014 fissure eruptions just north of the large Vatnajökull glacier. Dyngjusandur is an alluvial plain apparently kept barren by repeated mechanical weathering.

Informed by our 2013 expedition, we collected samples in nested triangular grids every decade from the 10 cm scale to the 1 km scale (as permitted by the size of the site). Satellite imagery is available for older sites, and for Mælifellssandur, Holuhraun, and Dyngjusandur we obtained overhead imagery at 1 m to 200 m elevation. “PanCam-style” photographs were taken in the field by sampling personnel. In-field reflectance spectroscopy was also obtained with an ASD spectrometer in Dyngjusandur. All sites chosen were 'homogeneous' in apparent color, morphology, moisture, grain size, and reflectance spectra at all scales greater than 10 cm. Field lab assays were conducted to monitor microbial habitation, including ATP quantification, qPCR for fungal, bacterial, and archaeal DNA, and direct cell imaging using fluorescence microscopy. Home laboratory analyses include Raman spectroscopy and community sequencing.

ATP appeared to be significantly more sensitive to small changes in sampling location than qPCR or fluorescence microscopy. Bacterial and archaeal DNA content were more consistent at the smaller scales, but similarly variable across more distant sites. Conversely, cell counts and fungal DNA content have significant local variation but appear relatively homogeneous over scales of > 1 km. ATP, bacterial DNA, and archaeal DNA content were relatively well correlated at many spatial scales.

While we have observed spatial variation at various scales and are beginning to observe how that variation fluctuates over time as biodiversity recovers after an eruption, we do not yet fully understand what parameters lead to the observed spatial variation. Home laboratory analyses will help us further understand the elemental and structural composition of the basaltic matrices, but further field analyses are vital for the understanding how temperature, moisture, incident radiation, and so forth influence the habitability of a microclimate.

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