INVESTIGATING ICELANDIC SOILS AS AN ANALOG FOR PEDOGENIC PROCESSES ON MARSC. N. Achilles[1], B. Sutter[2], R. Lybrand[3], D. W. Ming[4], A. C. Mcadam[5], G. Zaharescu[3], Z. Morse[6], C. Honniball[7], P. Whelley[1], J. Richardson[5], C. Barry[8], [1]Univ. Maryland College Park/NASA GSFC (cherie.n.achilles@nasa.gov), [2]Jacobs Technology/NASA JSC, [3]UC Davis, [4]NASA JSC, [5]NASA GSFC, [6]Howard Univ. [7]NASA GSFC/USRA, [8]ADNET Systems Inc./NASA GSFC

Introduction: Geochemical and mineralogical analyses of the martian surface indicate significant chemical weathering occurred early in Mars' history. In situ weathering and soil development (pedogenesis) is one mechanism proposed to occur on Mars. Although pedogenesis is a significant geochemical process on Earth's surface, it has not been explicitly confirmed on Mars. Establishing the presence of pedogenic weathering mechanisms on Mars requires measurements of elemental chemistry as a function of depth, a difficult analysis to achieve with the limited resolution of orbital instrumentation and limited mechanisms on rovers and landers. As a result, few martian in situ weathering profiles have been evaluated. The most promising are two ~10 cm trenches investigated by the Spirit rover [1-2]. Chemical gain/loss patterns suggest the downward transport of soluble species and a subsurface accumulation of Al and Si; two mechanisms typical in soil profiles [1]. Our limited knowledge of martian soil formation necessitates analog studies of these processes in basaltic soils on Earth.

The remote environments in Iceland's central highlands offer an exceptional opportunity to understand martian soil formation processes. Soils described in Iceland's central highland region are similar to the geologic profiles expected to occur on the martian surface. These analogs are poorly characterized, mainly due to the cold, harsh environment not suitable for vegetation or agricultural development [3]; however, these properties make this region an ideal Mars analog.

Field Investigation: In August 2021, the Goddard Instrument Field Team (GIFT) supported an expedition to the Icelandic highlands for martian and lunar analog research. Our sub-team's goals for the field expedition were to 1) use field portable instruments to assess soils *in situ* for comparison to past, current, and future Mars rover/lander instrument data sets, 2) investigate abiotic and biotic weathering mechanisms of basaltic minerals, and 3) understand the preservation of organic carbon in carbon-limited soils and compare observations to Mars Science Laboratory SAM (Sample Analysis at Mars) evolved gas analyses.

Sample sites were selected primarily in support of the carbon preservation study due to the hypothesis that older soils may preserve more C than younger soils. Sites 1 through 3 in Figure 1 illustrate a relative progression in soil age with Site 1 (proximal to the glacier) the youngest and site 3 the oldest. Site 4 was selected to compare changes in provenance and/or glass content on

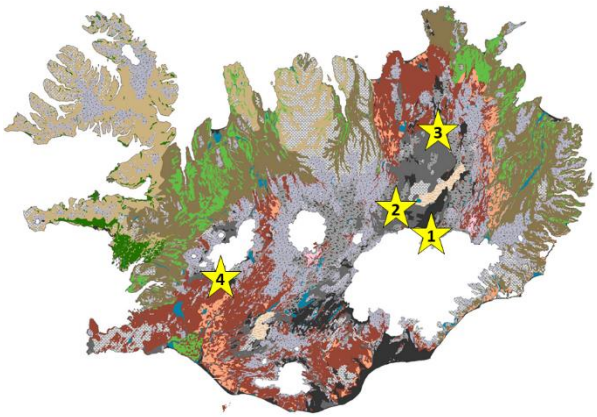

Figure 1. Iceland soils map from [4] modified with stars indicating the location of the four primary field sites.

weathering and soil formation. At each location, soil horizons were identified and described for each soil pit (Figure 2). Organically clean and non-organically clean sample was attained at each horizon for field instrument and laboratory mineralogy and geochemistry analyses.

Organic Carbon in Carbon-Limited Soils: Organically clean soil horizons will be analyzed to quantify and isotopically characterize C at each site. Data will be examined to assess factors that promote organic C preservation, and will be compared to MSL SAM evolved gas analysis (EGA) data to determine if similar processes occur on Mars. Additionally, this investigation will facilitate studies of organo-amorphous associations and whether such interactions are important in preserving organic C at these Mars analog sites.

In Situ Geochemistry & Mineralogy: Five field portable instruments were deployed to obtain *in situ* measurements of each soil horizon and produce the following data sets: XRD (X-ray diffraction) patterns and XRF (X-ray fluorescence), LIBS (Laser Induced Breakdown Spectroscopy), visible-near-IR(infrared)-shortwave-IR, and Raman spectra. Each data set is analogous to past, current, or future payload on Mars rover or lander missions. These coordinated measurements provide an analog perspective on soil analyses, enabling us to revisit past rover/lander datasets, and suggest sampling protocols and coordinated measurements for future robotic and/or manned missions.

Abiotic and Biotic Weathering Mechanisms: Laboratory analyses of sampled materials will allow for a more thorough characterization of chemical weathering

Figure 2. Soil pits at each of the four sites in Fig. 1.

mechanisms and how such processes may be analogous to Mars. Fine-scale investigations of soil horizons include imaging, geochemistry, mineralogy, and X-ray amorphous phase characterization using electron microprobe analyses, XRD, EGA, XRF, and ICP-MS (inductively coupled plasma-mass spectrometry) analyses. These laboratory measurements will complement the C study and offer insight regarding the limitations of *in situ* analyses. Furthermore, these data will enable a microscopic view of mineral weathering processes and the effects of biological activity in barren environments.

Status and Future Work: All field samples have been cataloged and are ready for processing and analysis. The majority of samples are currently being sieved to pre-determined size intervals for upcoming laboratory analyses. All laboratory analyses will be accomplished this calendar year. All field instrument data are currently undergoing processing and preliminary data show promising geochemical trends and correlations.

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References: [1] Amundson, R., et al. (2008) [2] Wang, A., et al. (2006) [3] Arnalds, O. (2015) [4] Arnalds, O. (2009)