ASKJA SAND SHEET, ICELAND, AS A DEPOSITIONAL ANALOG FOR THE STIMSON FM. IN GALE CRATER, MARS

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Introduction: Martian basaltic eolian sediments may record a long history of local and global climate change [1], and they may have been potential habitats where water, nutrients and organic carbon mixed below the surface [2]. Basaltic sand fields on Earth have not been characterized as well as felsic sands [3], but represent a unique analog to deposits such as the Stimson Fm. on Mars [4-8]. Eolian dominated weathering prevalent at Askja volcano, Iceland, likely also occurred on Mars and Askja mafic volcaniclastic dunes could be the best morphological and compositional analog for Martian eolian dunes [9].

Basalts from Askja, Iceland have high MgO (5-18 wt %) and high Fe_2O_3 (5-18 wt %: [3,10], this study) similar to Martian basalts, which have Fe_2O_3 from 10-33 wt % [11,12]) and MgO around 11 wt % [13]. Askja's cold desert climate provides a good weathering analog [14]. Askja is located in the Northern Volcanic Zone of Iceland [15] and basalts have been weathered to form mafic volcaniclastic deposits in a 40-km long sand sheet to the E-SE of the Askja caldera complex (Fig. 1). The 2014-2015 Holuhraun eruption was emplaced onto the southeastern part of the sand sheet (Fig. 1) and altered the regional geomorphology and may have impacted the geochemistry of the sand sheet itself by addition of wind-blown ash and crystals, plus weathering of the lava flow (MgO content of ~7.1 wt % [16]). Mangold et al. (2011) found that Icelandic sands show little chemical variations but that study was limited in the number of samples (12 sand samples and 12 rock samples) [3]. Here we expand on that study and we have created a morphological and geochemical database with the goal of identifying relevant trends to past and present Martian environments.

The Askja sand sheet, between ~10 cm and ~10 m thick, covers 240 km^2 [14]. Mountney and Russell described three distinct sections of the sand sheet. The SW section is deflationary and defined by very fine to medium grained basaltic sand with cobbles and boulders of lithologies sourced from adjacent to and distal from the sand sheet. The central part is inflating and is dominated by very fine-grained sand, relict lava fields, and small to large sand ripples. The NE portion is also inflating but that accumulation is limited to topographic depressions. The NE, characterized by sand mostly composed of pumice from the 1875 Askja eruption and basalt clasts from local lava fields, was not studied in detail here due to the difference in chemistry.

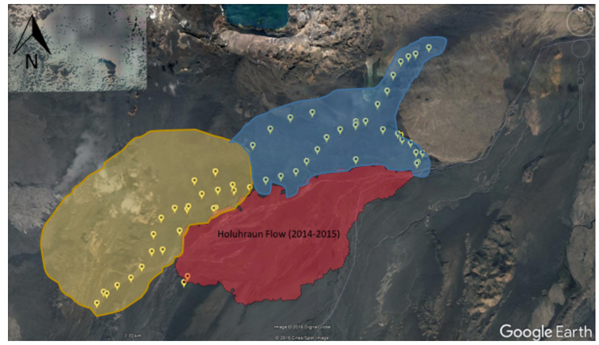

Figure 1. Google Earth image of the Askja sand sheet displaying sample locations The yellow represents the deflationary portion of the sand sheet and the blue the inflationary section. Samples were collected during the 2015 and 2016 field seasons. The red area represents the 2014-2015 Holuhraun lava flow [16].

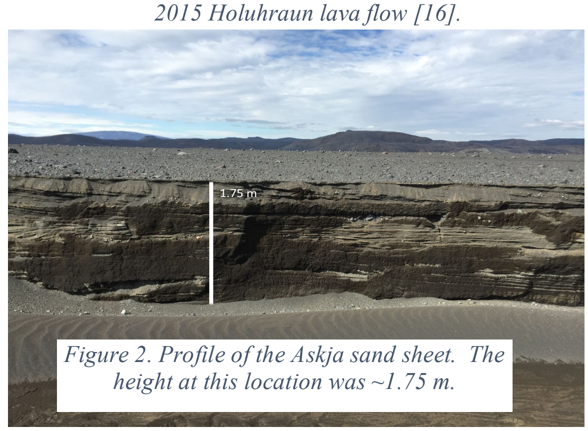

Figure 2. Profile of the Askja sand sheet. The height at this location was ~1.75 m.

Methods: We sampled 36 sites at Askja sand sheet of surface material and at 10 cm depth along a 25 km length traverse and an additional seven sites perpendicular to the main wind direction (E,NE [14]), totaling 225 samples (Fig. 1). We also sampled lava and volcaniclastic deposits that are adjacent to, and underlying the sand sheet, that may represent potential sources of the sedimentary material. Chemical composition was determined by standard ICP-MS methods [17]. Sphericity (presented as a percentage describing grain shape relative to a sphere, 100 representing a perfect sphere) and other grain size measurements were collected by a Retsch CAMSIZER. Current analyses include high-precision EPMA for major and trace element quantification of glass, mineral and lithic materials, SEM imaging of surface morphology of grains, and LIBS analysis to provide a direct comparison to ChemCam data collected on Mars.

Results Field observations establish the top ~1 cm to be composed of fine- to medium-grained sands composed of basalt lava fragments, volcanic glass, olivine, pyroxene, and plagioclase sourced from mafic lavas and explosive pyroclastic eruptions. Directly beneath is a very fine- to fine-grained consolidated layer largely composed of angular volcanic glass particles. Trenching to a depth of ~1 m indicates the sand sheet is dominated by mm-scale laminations and cross-bedded with varying thickness and grainsize. Most laminations are on the mm-scale, however, there are occurrences of thicker, cm-scale laminations and the presence of medium-grained sand wedges is also readily apparent.

Chemical analysis of sand samples reveals a composition similar to that of Martian crust (SiO_2: 48-52 wt %, MgO: 5-8 wt %, Fe_2O_3: 13-15 wt %). MgO concentrations vary with distance along the sand sheet, increasing by ~1.5 % over ~10 km in the downwind direction (E, NE), then maintaining a relatively consistent concentration of ~6.75 wt % over ~18 km (Fig. 2). This could be due to the influx of new material generated during the Holuhraun eruption (2014-2015; [18]). Mean sphericity displays a decrease of ~15 % to the E over ~10 km followed by a leveling off between ~65-75 %. This indicates the input of more material with an affinity to be prismoidal around 10 km. Also, the material at depth tends to be of higher sphericity than the material on and near the surface of the sand sheet. Notably, the MgO increases while the sphericity decreases and both data sets level off at ~10 km which suggests these two variables are related.

Discussion: The Stimson Fm., Gale Crater, Mars is a part of the Lower Mount Sharp group, and is a cross-bedded sandstone with visible sand grains. The lithified rock is primarily plagioclase feldspar, pyroxene, magnetite, and ~20-25 wt % XRD amorphous material [8]. The unaltered sections of the Stimson Fm. have been measured via APXS (Alpha Particle X-ray Spectrometer) to be compositionally similar to Martian crust [19]. Extensive cross-bedding and laminations chronicled by Curiosity are indicative of an ancient eolian-dominated dune system [5]. Fig. 3 is a profile of the Askja sand sheet which displays similar characteristics to the Stimson Fm. (mm-scale laminations, cross bedding, MgO & Fe_2O_3 content). This highlights the morphological and compositional similarities between the Stimson Fm. And the Askja sand sheet, and suggests that the sand sheet is a robust analog for the Stimson Formation.

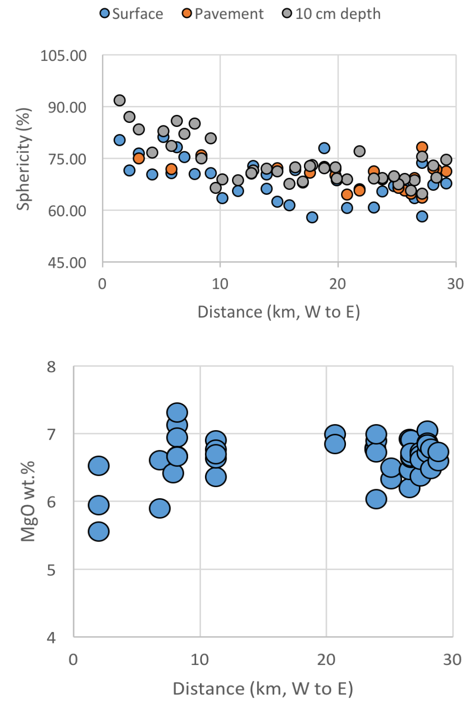

Figure 3. Top: Sphericity against longitude (in minutes of the W 16° longitude, W to E). Samples were collected on the surface, the fine-grained pavement beneath, and at 10 cm. Bottom: MgO wt% of sand samples against longitude (in minutes of W 16 longitude line). Samples were collected during the 2015 field season. All samples were collected along a ~27 km transect (Fig.1).

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