USING XRD TO CHARACTERIZE SEDIMENT SORTING IN A MARS ANALOG GLACIO-FLUVIO-EOLIAN BASALTIC SEDIMENTARY SYSTEM IN ICELAND. E. B. Rampe[1], R. C. Ewing[2], M. T. Thorpe[1], C. C. Bedford[1,3], B. Horgan[4], M. G. A. Lapotre[5], P. Sinha[4], M. Nachon[2], K. Mason[2], E. Champion[2], P. Gray[6], A. Soto[7], and E. Reid[8], [1]NASA Johnson Space Center, Houston, TX (email: elizabeth.b.rampe@nasa.gov), [2]Texas A&M Univ., [3]Lunar and Planetary Institute, USRA [4]Purdue Univ., [5]Stanford Univ., [6]Duke Univ., [7]Southwest Research Institute, [8]Mission Control Space Services.

Introduction: The martian surface has a primarily basaltic composition and is dominated by sedimentary deposits [e.g., 1-2]. Ancient layered sedimentary rocks have been identified across the planet from orbit [e.g., 2], have been studied in situ by the Mars Exploration Rovers and the Mars Science Laboratory rover [e.g., 3-4], and will be studied by the Mars 2020 rover [e.g., 5]. These ancient sedimentary rocks were deposited in fluvial, lacustrine, and eolian environments during a warmer and wetter era on Mars [e.g., 3-5].

It is important to study the composition of sediments in Mars analog environments to characterize how minerals in basaltic sedimentary systems are sorted and/or aqueously altered. This information can help us better interpret sedimentary processes from similar deposits on Mars and derive information about the igneous source rocks. Sediment sorting has been studied extensively on Earth [e.g., 6], but not typically in basaltic environments. Previous work has addressed sorting of basaltic sediments through experimental techniques [7] and in modern eolian basaltic systems [e.g., 8] and aqueous alteration in subglacial and proglacial environments [e.g., 9-10]. We add to this body of research by studying sediment sorting and aqueous alteration in a glacio-fluvio-eolian basaltic system in southwest Iceland.

Field site: Compositional and physical characteristics of sediments deposited in the fluvio-eolian system fed by the Þórisjokull glacier were studied in situ as part of the SAND-E: Semi-Autonomous Navigation for Detrital Environments project. One of the science objectives of the project is to examine and determine the causes of variability in the geochemistry and mineralogy of fluvial and eolian sediments along a sediment transport pathway. To address this goal, sediments were analyzed by handheld X-ray fluorescence (XRF) and visible/near-infrared (VNIR) spectroscopies and high-resolution imaging at three sites proximal, medial, and distal to the glacier. Surface sediment samples that corresponded to XRF and VNIR measurements were collected and returned for detailed mineralogical and geochemical analysis. Here, we provide a preliminary assessment of the mineralogy of surface sediment samples as determined by X-ray diffraction (XRD).

Samples and X-Ray Diffraction: Of the ~200 samples collected in the field, 26 were analyzed for quantitative XRD. Samples presented here represent the assortment of samples collected in the field, including fluvial and eolian sediments with a range of grain sizes collected at sites proximal (6.3 km), medial (11.3 km), and distal (14.4 km) from the glacial source (see [11-13] for information about grain size and geochemistry of the sediments). Fluvial sediments include dark sand-dominated samples collected from active or recently active channels that were transported as bed and suspended load and bright silt-dominated deposits that represent finer materials transported in the wash load of the proglacial streams (Fig.1). Some eolian sediments were collected in pairs, one sample from a ripple trough and one from an adjacent ripple crest. We report results from three such pairs here.

Sediments were pulverized in ethanol using a Retsch Zr mill. Micronized sediments were spiked with 20 wt.% Al_2O_3 as an internal standard then measured at the NASA Johnson Space Center on a Rigaku MiniFlex 6G from 5-70 °2θ with a Co source. Mineral and amorphous abundances were determined by Rietveld refinement using the Materials Data Inc. Jade software.

Figure 1. Performing in situ XRF measurements on silt (light-toned material) and sand (dark-toned material) in a recently active channel at the proximal site.

Results: All surface sediment samples comprise variable amounts of plagioclase feldspar, clinopyroxene (augite), and olivine (Fig. 2). Trace amounts (<1 wt.%) of hematite are present in every sample, and trace amounts of ilmenite were identified in some samples. X-ray amorphous abundances range from 0-20 wt.%. These mineralogical results are consistent with the identification of plagioclase-phyric and olivine-phyric basalt source rocks [13]. There is no evidence for phyllosilicates in the bulk powder. See [14] for discussion of aqueous alteration products in the <2 μm size fraction.

XRD results demonstrate separation between plagioclase and mafic minerals (i.e., pyroxene and olivine) within this basaltic sedimentary system. To visualize these separations, we plot plagioclase/pyroxene ratios in Fig. 3. Trends are similar for plagioclase/mafic mineral ratios (data not shown). Fluvial silt samples are generally relatively more enriched in plagioclase than mafic minerals compared to the fluvial sand samples. Fluvial sand samples from the distal site have lower plagioclase/pyroxene ratios than fluvial sand samples from the proximal and medial sites, indicating that distal fluvial sand samples are relatively more enriched in mafic minerals than other sites closer to the glacier. This result is corroborated by XRF measurements that show an enrichment in MgO and TiO_2 downstream [13]. Eolian sediments show low variability in mineral ratios compared to fluvial samples, and ripple crest samples appear to be more enriched in pyroxene than ripple troughs.

Discussion: The low abundance of amorphous materials in all samples suggests that subaerial lavas, rather than subglacial volcanic deposits, are the main source of the sediments. The dominance of minerals over amorphous materials is uncommon in Icelandic sand sheets [e.g., 15] and demonstrates that this field site is useful for understanding mineral sorting along a Mars analog fluvial-eolian sediment transport pathway.

Mineral variability within this glacio-fluvio-eolian basaltic sedimentary system indicates hydrodynamic sorting is affecting sediment composition. The enrichment in plagioclase relative to mafic minerals in the fluvial silt samples demonstrates that the wash load preferentially carries plagioclase, either because it is concentrated in the finest fraction or because it is less dense than mafic minerals. The relatively low plagioclase/pyroxene ratios of the fluvial sands at the distal site suggest that mafic minerals become concentrated downstream, either through hydrodynamic sorting or because of a mafic mineral-rich local source. The lavas of the Skjaldbreiður volcano at the distal site are plagioclase-phyric [13], suggesting hydrodynamic sorting of fine-grained mafic minerals in the bed load is responsible for the enrichment in mafic minerals downstream. Similar results have been recognized in fluvio-lacustrine deposits in Gale crater, Mars [16]. The low variability in mineral ratios in the eolian sediments may indicate that eolian processes homogenize local fluvial sediments.

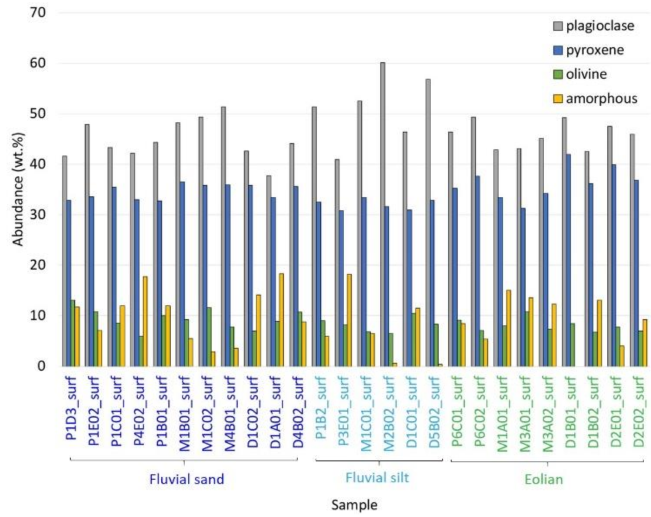

Figure 2. Plagioclase (gray), pyroxene (blue), olivine (green), and amorphous (yellow) abundances for fluvial sand, fluvial silt, and eolian samples.

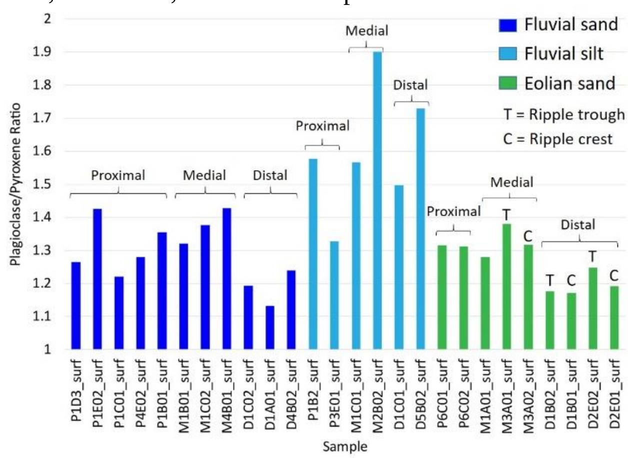

Figure 3. Plagioclase/pyroxene ratios of fluvial sand, fluvial silt, and eolian sand samples from the proximal, medial, and distal sites.

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