MINERALOGICAL MEASUREMENTS OF MARS-ANALOG ESKERS FROM ICELAND.

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Introduction: Orbital morphological observations of Mars demonstrate evidence for glaciation in the Hesperian and Amazonian eras [e.g., 1-2]. The discovery of sinuous ridges in association with relatively young (~100s Ma) buried glaciers suggests recent wet-based glaciation led to the formation of eskers [e.g., 3]. It is important to be able to discriminate eskers on Mars from other sinuous ridges (e.g., inverted river channels) to better characterize past aqueous environments on Mars and their potential as habitable environments. Our group is studying the geomorphology, sedimentology, and mineralogical composition of Mars-analog eskers in Iceland to identify signatures of eskers that would enable us to positively identify them on Mars [4]. Here, we present mineralogical measurements of sediments collected from eskers and the surrounding proglacial plains at the terminus of Breiðamerkurjökull in southeast Iceland (Figure 1) to determine whether the mineral assemblage within eskers can be used to uniquely identify them on the martian surface.

Methods: In the summers of 2022 and 2023, we collected sediment samples from eight eskers that have different exposure ages (i.e., when the glacier margin retreated to reveal the features). We categorize these eskers into three broad classes based on age (Figure 1): (1) stable eskers (the oldest, ~60-80 years), which have no ice core, a stable morphology, and soil development; (2) evolving eskers (~5 years), which have no ice core but are still being actively modified via fluvial processes, and have an induration crust; and (3) emerging eskers still in the process of being exposed (the youngest), which are still ice-cored, partially encased in ice channels, and are experiencing rapid morphological change. We report on the mineralogy of two stable eskers (nicknamed "The Ring" and "Elves Labyrinth"), two evolving eskers ("Pristine Baby" and "Trollercoaster"), and an emerging esker ("Emerging Esker").

Quantitative mineralogy of esker samples was determined via X-ray diffraction (XRD) and Rietveld refinement. Sediments were first sieved to the <2 mm

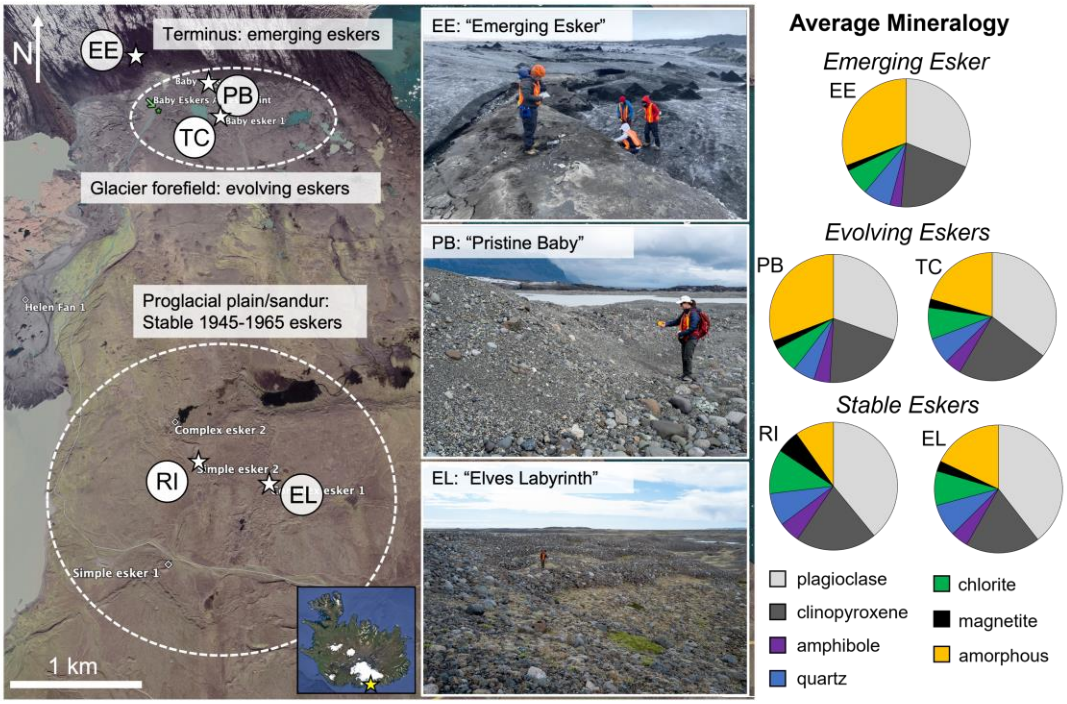

Figure 1. (Left) Orbital view of field site with locations of five eskers: Emerging Esker (EE), Pristine Baby (PB), Trollercoaster (TC), The Ring (RI), and Elves Labyrinth (EL). (Middle) Photos of three eskers of different ages. (Right) Averaged mineral and amorphous abundances for samples from five eskers.

size fraction to study the matrix materials in eskers (i.e., to exclude cobbles). This bulk fraction was crushed in a micronizing mill, and the resulting powder was spiked with corundum. Spiked powders were analyzed on a Panalytical X'Pert Pro MPD instrument at NASA JSC. Rietveld refinement was performed using the HighScore Plus and MDI JADE software packages. Select samples were sieved into different size fractions (1-2 mm, 0.5 to 1 mm, 250-500 µm, 63-250 µm, and <63 µm), then prepared for quantitative powder XRD as above, to evaluate mineralogical differences with grain size.

Results: Mineralogical measurements demonstrate the esker sediments are typically dominated by plagioclase feldspar and clinopyroxene; contain minor abundances of amphibole, quartz, and chlorite; have trace magnetite; and contain an X-ray amorphous component (Figure 2). The relative abundance of the X-ray amorphous materials is dependent on the age of the esker and the grain size/facies from which the sample was collected. Averaged mineral and X-ray amorphous abundances for each esker show that the stable esker "The Ring" has the least amorphous material of all eskers (10 wt.%), whereas Emerging Esker has the most (31 wt.%) (Figure 1). The sediment samples that contain the greatest abundances of X-ray amorphous materials are typically dark in color, matrix supported, and dominated by medium to fine sand. Analyses of size separates demonstrate that X-ray amorphous materials are most abundant in the medium to fine sand grain size classes (Figure 3).

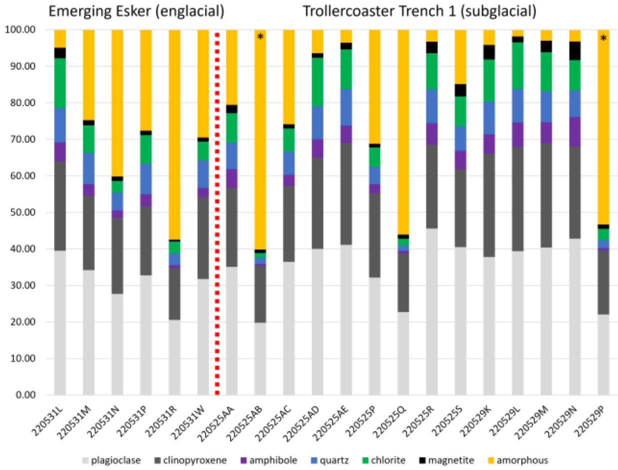

Figure 2. Bulk mineralogical results from samples collected from Emerging Esker (to the left of the red dashed line) and a trench dug from Trollercoaster (to the right of the dashed line). Trollercoaster samples with asterisks at the top were collected from onlapping sediments that may be lake deposits that post-date esker emergence.

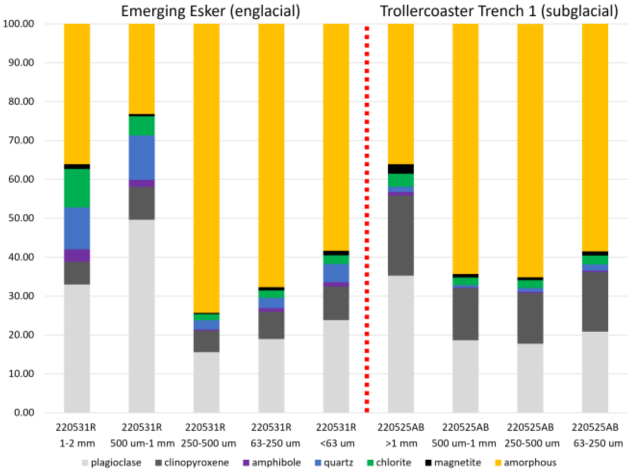

Figure 3. Mineralogical results of grain size separates of a sample from emerging esker (to the left of the red dashed line) and from Trollercoaster (to the right of the red dashed line).

Discussion: Mineralogical data from XRD show the presence of minerals identified on the martian surface, including plagioclase, clinopyroxene, quartz, chlorite, and magnetite, and the presence of an X-ray amorphous component, demonstrating compositional fidelity as a Mars analog. We do not find crystalline secondary phases in the bulk sediment samples or the size separates, suggesting water-sediment interactions in these eskers do not produce secondary minerals. X-ray amorphous materials can be primary (e.g., volcanic glass) or secondary (e.g., allophane) in cold and wet Mars analogs [e.g., 5-6]. The concentration of amorphous material in the sand size fraction suggests that amorphous materials are dominated by volcanic glass/ash/tephra, rather than secondary materials. Mineralogical and structural analyses of the <2 µm size fraction will be performed to evaluate the formation of secondary amorphous and short-range order materials in these environments.

We hypothesize that the deposition of glass/ash/tephra is controlled by the energy of the fluvial environment and source of the sediments (e.g., supraglacial, subglacial). Aqueous alteration could also explain lower amorphous abundances in older eskers.

Acknowledgments: This work was funded by NASA SSW grant 80NSSC21K0908.

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