# EXAMINING THE TRANSPORT OF VOLCANIC SEDIMENT FROM VATNAJÖKULL USING DECORRELATION STRETCHES (DCS).

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**Introduction:** Basaltic sand is widespread on the martian surface and has been studied through analog, orbital, and surface mission studies, including the current Mars Science Laboratory and Mars 2020 missions [1, 2]. However, there is still a need to better constrain specific transport pathways from sediment source to their present location. The dominant basaltic composition and cold climate make Iceland an ideal Mars analog to study sediment transport [3]. One of the science goals of Semi-Autonomous Navigation of Detrital Environments (SAND-E) team is to examine variability in sediments along a transport pathway by looking at sites proximal, medial, and distal from their source with a combination of field and lab work. This work complements sample-based studies [4] by analyzing aerial images using color variability as observed by decorrelation stretched images. We focus on sediments sourced from Vatnajökull, the largest source of sand in Iceland, that are transported northeast by aeolian and fluvial processes to their sink in the Atlantic Ocean [5]. If the images show a clear pattern in transport path of sediments, a source and alteration extent can be determined. If successful, this method can be remotely applied to other planetary surfaces.

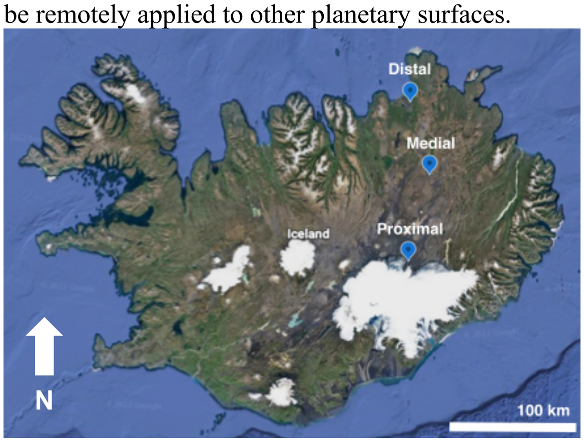


**Figure 1.** Landsat/Copernicus image of sample sites in Iceland.

**Methods**: To analyze the variation in the sediment, screenshots were taken from satellite and aerial images provided by Loftmyndir ehf (http://map.is). A mosaic of screenshots was manually created for each sampling site analyzed by the SAND-E team: (1) proximal, (2) medial, and (3) distal (Fig. 1). The mosaics were loaded into ENVI and a decorrelation stretch (DCS) was performed. DCS is a color enhancement process that exaggerates the color variability of an image by suppressing correlated components like albedo. Previous work in Iceland has shown that the colors in these sediments correlate with different compositions [6]. Expected spectral signatures include pyroxene, olivine, glass, and hyaloclastite, since those are often present in basaltic sand fields in Iceland [7]. The DCS images of the sites are qualitatively compared to look for compositional changes down system.

Because the mosaics are screenshots of satellite data, the only color channels available are red, green, and blue in visible light. Vegetation cannot be masked without masking out sediment that reflects mostly green. This means that the green that shows up in the DCS images could either be vegetation or olivine.

**Proximal**: The proximal site (Fig. 2a) is located north of Vatnajökull, a glacier in eastern Iceland. The sample area is a few hundred meters east of a glacier moraine. In the DCS image (Fig. 2b), the colors are most heterogenous relative to sites farther down system (Figs. 2d/f). The youngest sediments at lowest elevations near the active fluvial system emerging from the glacier (Jökulsá á Fjöllum) are deep blue, while the next oldest abandoned channel at higher elevations to the northeast exhibits purple mixed with dark green. The river channel cuts through a series of alluvial fans transporting sediments from nearby volcanic edifices to the southeast, which contribute spectrally distinct sediments where they enter the proximal site. A distinct distributary deposit onto the upper slopes of the Jökulsá á Fjöllum valley is very bright orange and appears to be sourced from a fan/channel system originating in bright orange mounds to the south. Just to the north of this, the river channel cuts through a magenta fan and a stream channel with additional red margins, partially sourced from nearby red mounds.

Blue areas are consistent with high pyroxene content. Orange represents the presence of hyaloclastite. The red area represents oxidized (likely hematite-enriched) rocks. Yellow represents fine glassy hyaloclastite sediments while purple represents volcanic glass grains. The more cool-colored portion may be a mixture of compositions, most likely hematite and vegetation.

**Medial**: The medial site (Fig. 2c) is about 100 km north of the proximal site. The DCS for the medial site (Fig. 2d) has color variability similar to what is observed in the proximal site (Fig. 2b). Areas of beige/orange sediment in the true color image (Fig. 2c) have a much stronger orange hue, and the isolated patch of orange in the northwest is connected to a thin channel to the east, a possible localized sediment input. The

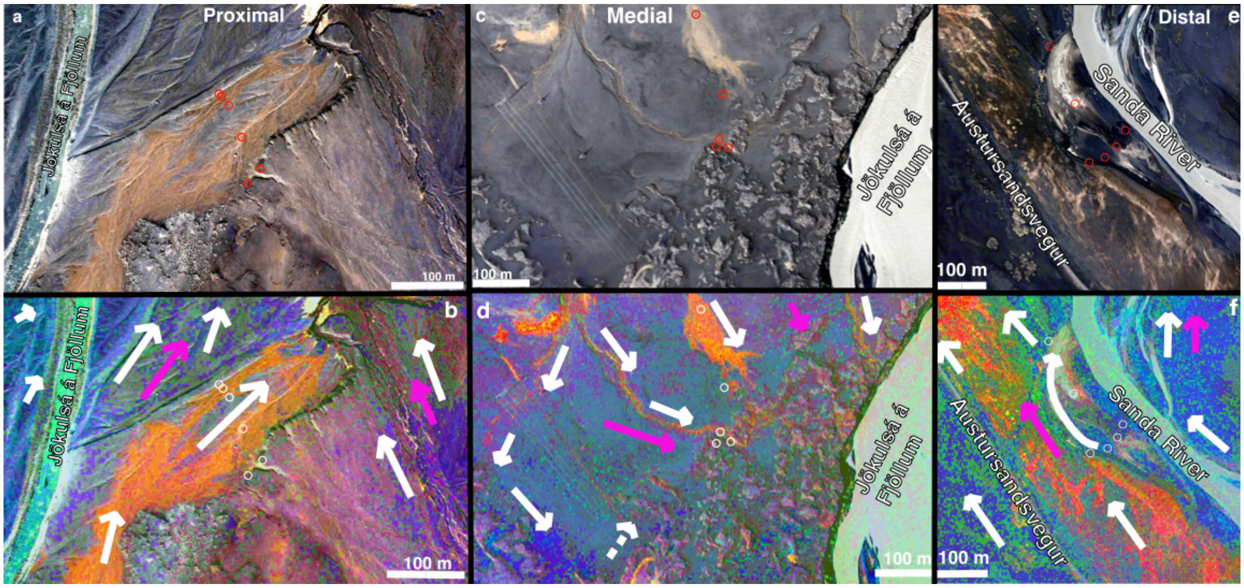


**Figure 2.** True color images of the (a) proximal (c) medial and (e) distal sites. Locations where sediments were sampled during traverse simulations by the SAND-E team are marked with red dots. These are compared to DCS images of the sites (b, d, f). The solid white arrows indicate local sediment transport directions. Solid pink arrows indicate regional sediment transport directions. Dashed white arrows indicate uncertain sediment transport directions. The sampling locations are marked with circles.

orange patches also display some localized patches of yellow. Due to elevations decreasing from west to east, these beige sediments are being transported towards the river. The pillow lavas are purple with specks of orange. The orange channels are bordered by purple, signaling that other types of sediments are being transported towards the river as well. The southwest corner has a patch of dark blue just east of the southwestern pillow lavas.

The orange areas with yellow specks are hyaloclastites. The dark blue represents pyroxene. The violet may be mixing between pyroxene and glass. The dark teal may be a mix between pyroxene and olivine.

**Distal**: The distal sample site (Fig. 2e) is in the Jökulsá á Fjöllum delta of the main system. The DCS of the distal site (Fig. 2f) has the least color variability relative to proximal and medial. Elevation decreases from southeast to northwest in the direction of the Atlantic Ocean. Sediment to the east of the river is dark blue, but with areas of teal speckled throughout. This sediment follows the direction of the river, traveling northwesterly then changing to a northerly direction. In between the Sanda river and the Austursandsvegur, the sediment is a mix, with the northwest having a bright orange and yellow, the southeast having a pink and orange. These sediments have a consistent northwesterly transport direction.

The blue sediment is pyroxene. The green, especially the brighter parts, may be vegetation. The orange/yellow mix is hyaloclastite. The orange/pink mix is hematite-enriched sediment. The yellow circular nodules are hay bales.

**Discussion**: As the sediment travels downstream, composition variability, as qualitatively derived from color variability in DCS images, decreases. Proximal has a similar amount of pyroxene, hyaloclastite, glass, and hematite, with a portion that looks to be a mixture of hematite and possibly vegetation or olivine. In the medial site, pyroxene is more dominant, covering approximately half of the DCS image, with significant portions of hematite, hyaloclastite, and glass. The distal site is also dominated by pyroxene, with a significant portion of hyaloclastite. This shows that as sediments travel downstream from their source, they become more homogenized in their composition. Specifically, the relative amount of pyroxene becomes more prominent from proximal to distal, while the amount of hematite decreases. The amount of hyaloclastite appears consistent throughout the system. The amount of volcanic glass is abundant in proximal and is reduced down system. We hypothesize that pyroxene is more readily transported in this system. However, sediment transport directions show that while the proximal and distal sites studied sediments that are affected by fluvial transport, the medial site sediments are outwash plains that are much more affected by aeolian transport. When applying this technique to Mars, we would expect sediment deposits with a higher pyroxene abundance to be farther from the sediment source.

**References**: [1] Blake et al. (2013) *Science*, *341.* [2] Farley et al. (2022) *Science*, *377.* [3] Ehlmann et al. (2012) *JGR: Planets, 117.* [4] Rudolph et al., this volume. [5] Arnalds et al. (2016) *Aeolian Research, 20* 176–195. [6] Sinha et al. (2021) LPSC #2548. [7] Mangold et al. (2011) *Earth Plan. Sci. Letters, 310* 233-243.