CHARACTERIZING THE BASALTIC IGNEOUS AND VOLCANICLASTIC PROVENANCE AT A MARS ANALOG SITE IN ICELAND WITH THE DIGMARS TEAM. A. R. Putnam[1], M. T. Thorpe[2], C. C. Bedford[2,3], V. Tu[4], G. Costin[1], M. Wilcox[1], R. Kovtun[1], E. B. Rampe[4], J. J. Tamborski[5], K. Lynch[3], D. Leeb[6], G. Gundjonsson[6], and K. L. Siebach[1], [1]Rice University Department of Earth, Environmental, and Planetary Sciences, Houston, TX (audrey.putnam@rice.edu), [2]NASA JSC, JETS, [3]Lunar and Planetary Institute, [4]NASA JSC, [5]Old Dominion University, [6]Iceland Space Agency.

Introduction: NASA's *Curiosity* and *Perseverance* rovers are exploring ancient sedimentary lake basins on Mars with dominantly basaltic provenance regions [e.g. 1-3]. Analysis of sedimentary rocks in Gale crater has shown that the dominantly basaltic source materials were subject to mineral sorting, likely via both igneous and sedimentary processes [1-2], and minor weathering similar to the degree of weathering that occurs in Iceland [4]. Unfortunately, neither rover has yet been able to directly access the source terrains, and there are few studies of weathering and sedimentary rock-forming processes in analogous cold, basaltic terrestrial watersheds. **We seek to characterize the volcanic and volcaniclastic lithologies in an analogous watershed to better distinguish likely igneous and secondary processes.**

The Digging Iceland Geology for Mars Analog Research Science (DIGMARS) team completed a field season in August 2021 investigating a Mars analog site where a dominantly basaltic provenance feeds lake deposits at Sandvatn in southwestern Iceland (see Thorpe et al., this LPSC, and Fig. 1). **Here, we describe the range of textures and lithologies present in the lake provenance to capture (1) how basaltic source characteristics contribute to sediments and (2) a description of analogues that may be present in the source terrains of Martian sedimentary basins.**

Geologic Context: Sandvatn is a 5 km diameter lake in the Icelandic Highlands along the Western Volcanic Zone [5]. It is dominantly fed by meltwater off the Langjökull glacier via Hagavatn, an upstream proglacial lake, which drains via the Fár river into Sandvatn. The Fár river runs alongside the Jarlhettur hills, which are a tindar, or an isolated ridgeline formed by subglacial volcanism, postulated to be from the last glacial period [5-6]. The terrain immediately around the lake has previously been mapped as interglacial basalts and intercalated volcaniclastics of the late Pleistocene Móberg formation [7,8]. The location of the vent that formed this volcanic terrain is unclear.

Glaciovolcanic Terminology: The thermal shock of quenching hot lava or ash with ice or water can produce volcaniclastic breccias and/or sandstones with amorphous materials [e.g. 5-9]. Glaciovolcanic rocks have been previously characterized as potential analogues for Mars due to amorphous materials on that planet and the potential for glaciovolcanism in the past [10-12]. Some of the relevant amorphous materials are primarily characterized in thin sections. Sideromelane is a variety of basaltic glass that forms from quenching of a melt in contact with water or wet sediment [13] and is a common product of submarine, sublacustine, and/or subglacial volcanism [13]. Sideromelane is commonly altered to palagonite, an amorphous/microcrystalline alteration product that typically appears orange in thin section (Fig. 2) [14]. Palagonitization occurs either via long term burial diagenesis or quickly via syn-eruptive hydrothermal activity [15].

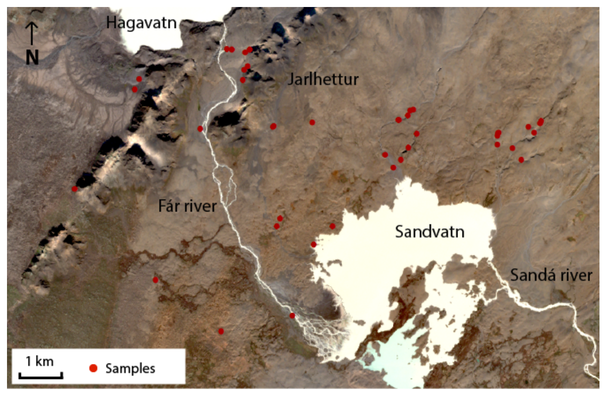

Figure 1: Sample locations in red dots

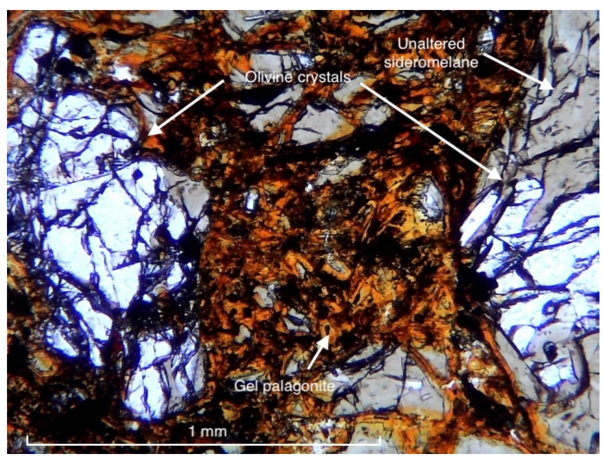

Figure 2: Photomicrograph from a dark red hyaloclastite breccia

Methods: We collected 81 bedrock and streambed sediment samples from the Sandvatn watershed (Fig 1). The goal of our sampling strategy was to characterize all potential inputs to the lake sediments. Back in the lab, select source samples were ground to <30 microns using a micronizing mill, spiked with 20 wt% Al_2O_3, and analyzed on a Rigaku Miniflex X-ray Diffractometer. Thin sections of six samples meant to represent the range of lithologic diversity were made and analyzed with a petrographic microscope.

Results: We identifed seven endmember lithofacies, which grade into one another in many outcrops.

a) Massive, planar basalts These are thick deposits of massive igneous rock with individual layers of ~10 cm to ~6 m thickness. Individual layers pinch out in some outcrops. They vary significantly in vesicularity both between and within outcrops and sometimes show ropey pāhoehoe textures indicative of surface flows. The thin section of a sample from the core of a ~1.5 m thick layer is mostly crystallized with only small pockets of glass. It is dominantly composed of plagioclase microlites, interstitial clino- and orthopyroxenes, and olivine phenocrysts.

b) Basalt pseudopillows These are irregular rounded "blobs" of basaltic rock up to a few meters across that have radial fractures and glassy rims visible in outcrop. The pseudopillows are typically found within finer grained or brecciated matrix lithofacies (described as other lithofacies below). This lithology contains plagioclase and olivine micro-phenocrysts, plagioclase microlites, opaque glass, and interstitial clinopyroxene. In thin section, the rim shows skeletal plagioclase crystals, increased glass content, and a rim of vitrophyric sideromelane indicating quenching.

c) *Jigsaw-fit breccias of monomict fractured basalt without matrix.* These are clast-supported breccias that appear to be comprised of a single basaltic lithology. The basalt clasts range from 10s of centimeters to several meters in diameter.

d) Cobble-sized hyaloclastite breccias. Hyaloclastite breccias are composed of the products of quench fragmentation, usually dominantly sideromelane. Some are clast supported and others are matrix supported, but with <60% matrix. The matrix varies in color from yellow-tan to dark orange and red. The thin section of a dark orange sample is composed of vitrophyric (glass fragments that include crystals) sideromelane with a medium degree of palagonitization and abundant iron oxides. The included crystals are olivine and plagioclase.

e) Matrix supported hyaloclastite breccias with pebble and smaller sized clasts These represent a distinct lithofacies comprised of >70% tan matrix. In thin section, the larger clasts are vitrophyric sideromelane with minor palagonitization clasts and basalt clasts in a matrix composed of flow layering of plagioclase and olivine crystal fragments and fine glassy tephra.

f) Polymict lapilli tuff. One such tuff was identified in the Sandvatn source region. It consists of a variety of basaltic clasts varying from mostly opaque (tachylite) vitrophyric clasts to holocrystalline microcrystalline clasts and breccia lithoclasts made of vitrophyric sideromelane fragments. All clasts float in a matrix dominated by small plagioclase and olivine crystaloclasts.

g) Ash There are thick (up to ~6 m) ash layers in north of Sandvatn. Many occurrences appear to drape over the modern landscape, though at least one is in the stratigraphy between coherent basalt and breccia. Several outcrops contain angular basalt clasts.

XRD Results Across all samples, primary igneous minerals (e.g. plagioclase and pyroxene) dominate and the most notable differences lie in the proportion of the X-ray amorphous component.

Summary and Future Work: The source terrain of Sandvatn is complex and includes coherent basalts and basaltic volcaniclastic rocks with a wide range in grain sizes of eroded clasts, crystallinity, and alteration. This heterogeneity may be similar to Martian source terrains that formed from the interaction of volcanism with water/ice. Future work will include the analysis of streambed and lake sediments from Sandvatn to characterize how this complexity is reflected in the sediments.

Acknowledgments: We acknowledge funding from the NASA Solar System Workings Program, project NASA SSW grant 19-SSW19-0300. We are grateful for the support of the Iceland Space Agency in the field.

References: [1] Siebach, K. L., Baker, M. B., Grotzinger, J. P., McLennan, S. M., Gellert, R., Thompson, L. M., & Hurowitz, J. A. (2017). *JGR: Planets*, *122*(2), 295-328. [2] Payré, V., Siebach, K. L., Dasgupta, R., Udry, A., Rampe, E. B., & Morrison, S. M. (2020). *JGR: Planets*, *125*(8), e2020JE006467. [3] Goudge, T. A., Mustard, J. F., Head, J. W., Fassett, C. I., & Wiseman, S. M. (2015. *JGR: Planets*, *120*(4), 775-808. [4] Thorpe, M. T., Hurowitz, J. A., & Siebach, K. L. (2021). *JGR: Planets*, *126*(2), e2020JE006530. [5] Sinton, J., Grönvold, K., & Sæmundsson, K. (2005). *Geochem, Geophys*, *6*(12). [6] Bennett, M. R., Huddart, D., & Gonzalez, S. (2009). *Quat. Sci. Rev.*, *28*(7-8), 647-676. [7] Sigurdsson, H., Schilling, J. G., & Meyer, P. S. (1978). *JGR: Solid Earth*, *83*(B8), 3971-3982. [8] Jakobsson, S. P., & Gudmundsson, M. T. (2008). *Jökull*, *58*, 179-196. [9] Gudmundsson, M. T., Pálsson, F., Björnsson, H., & Högnadóttir, *H.* (2002). *Geol. Soc., London, Special Publications*, *202*(1), 319-335. [10] Head, J. W., & Wilson, L. (2007). *Ann. Glaciology*, *45*, 1-13. [11] Bishop, J. L., Schiffman, P., & Southard, R. (2002). *Geol. Soc., London, Special Publications*, *202*(1), 371-392. [12] Ackiss, S. E., Horgan, B., Gudnason, J., Haberle, C., Thorsteinsson, T., & Thordarson, T. (2017) *LPS XXXVIII* Abstract #1964. [13] Farrand, W. H., Wright, S. P., Glotch, T. D., Schröder, C., Sklute, E. C., & Dyar, M. D. (2018). *Icarus*, *309*, 241-259. [14] Peacock, M. A., & Fuller, R. E. (1928). *Amer. Miner.: J Earth and Planetary Materials*, *13*(7), 360-383. [15] Stroncik, N. A., & Schmincke, H. U. (2002). *Int. J. Earth Sci*, *91*(4), 680-697. [16] Pauly, B. D., Schiffman, P., Zierenberg, R. A., & Clague, D. A. (2011). *Geochem, Geophys*, *12*(12).