WEATHERING AND SEDIMENTATION IN BASALTIC TERRAINS ON EARTH; IMPLICATIONS FOR THE PALEOCLIMATE OF GALE CRATER, MARS. M. T. Thorpe[1], J. A. Hurowitz[2], and K. L. Siebach[3], [1]Jacobs, JETS, NASA JSC, Houston (michael.t.thorpe@nasa.gov), [2]Stony Brook University, [3]RiceUniversity.

Introduction: In the Early Hesperian period, rivers transported detritus from igneous source terrains to a downstream lake within Gale crater, Mars, creating a stratified stack of fluviolacustrine rocks that is currently exposed along the slopes of Mount Sharp [e.g., 1-2]. Debate still exists regarding the paleoclimate that supported overland flow of liquid water at Gale crater, in large part because little is known about how chemical and mineralogical paleoclimate indicators from mafic-rock dominated source-to-sink systems are translated into the rock record. Here, we present the findings from *Thorpe et al*., (2021), where we compiled data from basaltic terrains with varying climates on Earth in order to provide a reference frame for the conditions that may have prevailed during the formation of the sedimentary strata in Gale crater, particularly focusing on the Sheepbed and Pahrump Hills members.

Data Sources: Terrestrial geochemical reference values from the literature were gathered for soil weathering profiles and sediments in basaltic terrains from around the globe (4-15). We attempt to span a range of climatic variables and particularly focus on sediments from Iceland (15) and Idaho (16), as studies from these field sites have well-documented sedimentology, geochemistry, and mineralogy. Martian datasets were collected by the Curiosity rover and compiled from the literature. Major element geochemistry from the Alpha-Particle X-ray Spectrometer (APXS) was used for (i) 41 mudstone analyses from the Sheepbed member of the Yellowknife Bay (YKB) formation (16) and (ii) 44 analyses of mudstones from the hematite–phyllosilicate (HP) facies at the Pahrump Hills member of the Murray Formation (17). Additionally, mineral abundance, as modeled from powder diffraction patterns acquired by the Chemistry and Mineralogy (CheMin) instrument X-ray diffractometer onboard Curiosity, were compiled for (i) two mudstone analyses from the Sheepbed member from the Bradbury group (18) and (ii) two mudstone analyses from the Murray HP facies from the Mount Sharp group (19) for comparison to terrestrial analyses.

Data Analysis: For terrestrial datasets, we only consider sediments and sedimentary rocks with grain sizes <63 µm, referred to as the mud fraction in sedimentological studies and for martian data we only consider mudstones where the grain size is below the resolution on the MAHLI imager onboard Curiosity. For the mineralogy, a first order comparison of phase identification and abundances was completed. For the geochemistry, the chemical index of alteration (CIA; ref 9) was employed. The CIA (CIA= $((Al_2O_3 / Al_2O_3 + CaO + Na_2O + K_2O) * 100)$ is a molar ratio that juxtaposes the behavior of an immobile element against those elements easily mobilized during incongruent weathering of minerals and glass by aqueous solutions

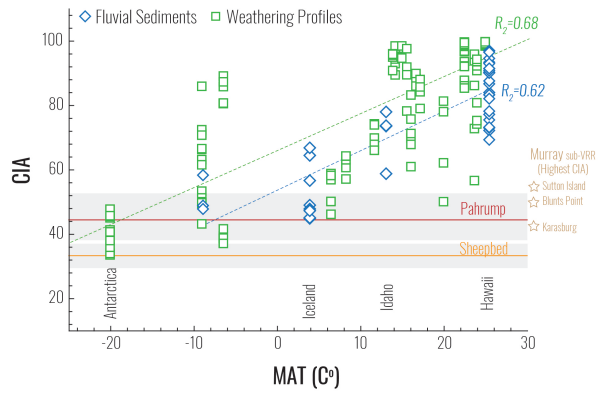

Figure 1. Mean annual temperature plotted vs. the chemical index of alteration for terrestrial reference values and the CIA range for martian sedimentary rocks.

Discussion and Conclusions: From our literature compilation, MAT and grain size appear to be the major variables most strongly correlated with CIA variations in martian analog terrains. Therefore, directly comparing similar grain sizes across planets allows us to effectively understand the impact of temperature on CIA. Terrestrial mud-sized materials from analog environments and martian mudstones display not only remarkable similarities but also distinct differences that help constrain the paleoclimate in ancient Gale crater. The results of this work suggest that the paleoclimate of Gale crater was variable, with our terrestrial reference frame providing a baseline approximation of an ancient martian climate that shifted toward Icelandic-like conditions from even more frigid temperatures over the course of sedimentation in the ancient lake.

References: [1] Grotzinger, (2014) *Science.* [2] Grotzinger, (2015) *Science.* [3] Thorpe et al., (2021) *JGR Planets*. [4] Caner et al., (2014), *Geoderma*. [5] Craig & Loughnan, (1964), *Soil Research*. [6] De Carlo et al., (2005), *Applied Geochemistry*. [7] Gibson et al., (1983), *JGR*. [8] Ma et al., (2007), *GCA*. [9] Nesbitt, H.W. and Wilson, (1992), *American Journal of Science*. [10] Pokrovsky et al., (2005), *GCA*.[11] Porder et al., (2007), *EPSL*. [12] Rasmussen et al., (2010), *Geoderma*. [13] Yesavage et al., (2015), *Icarus*. [14] Thorpe and Hurowtiz, (2019), *Chemical Gelogy*. [15] Thorpe et al., (2020), *GCA*. [16] McLennan et al., (2014), *Science*. [17] Hurowitz et al., (2017), *Science*. [18] Vaniman et al., (2014), *Science*. [19] Rampe et al., (2017), *EPSL*.

Acknowledgments: Data sets for this work are archived on a FAIR repository Thorpe et al., (2021) and all martian data is available on the Planetary Data System Geoscience Node (PDS).