Detection of Organics in Icelandic Hot Spring Deposits with Implications for Organics Preservation in Relict Martian Hot Spring Environments. E.J. Prescott[1], A.J. Williams[1], K.L. Craft[2], J.R. Skok[3]. [1]University of Florida Department of Geosciences (eprescott@ufl.edu), [2]Johns Hopkins University Applied Physics Laboratory, [3]SETI Institute.

Introduction: Unique microbial ecosystems inhabit hydrothermal spring environments. These environments have the capacity to preserve biosignatures left by microbial cells within siliceous sinter layers deposited by the springs [1]. The discovery of hydrothermal deposits on Mars [2] has recategorized terrestrial hot springs as Mars-analog environments, driving forward the study of biosignature preservation in these settings to help prepare future missions to Mars. This study quantifies the organics detectable by SAM-instrument like (*Curiosity* rover) pyrolysis gas chromatography mass spectrometry (py-GC-MS) without derivatization in three Icelandic hot-spring deposits ranging from modern and active, modern and altered, and relict.

Field Site: The Icelandic hot spring sinter deposit sites located at Hveravellir, Gunnuhver, and Lýsuhóll represent active, altered, and relict hot spring depositional environments, respectively. Hveravellir is actively discharging geothermal water. We define Gunnuhver as "altered" due to its active fumaroles overprinting existing silica sinters. Lýsuhóll is currently inactive, cold, and eroding, denoting it as "relict". By sampling these spring systems, which represent various ages and degrees of preservation, we can begin to understand how well organic biosignatures are preserved over time and with hydrothermal and diagenetic alteration.

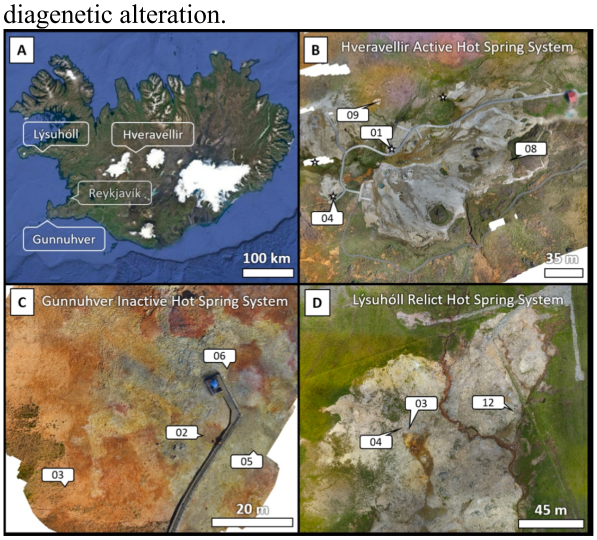

Figure 1: A Satellite imagery of Iceland with capital Reykjavik and (B-D) sample sites Hveravellir, Gunnuhver, and Lýsuhóll,] with sampling sites labeled [3].

By exploring the preservation of organic matter from extremophile microbes in terrestrial siliceous sinter, it is possible to extrapolate the degree of organic preservation possible for hydrothermal siliceous sinter samples on Mars. The sinter samples for this project were collected at the surface and subsurface from 2 cm to 18 cm in depth from spring vent to distal apron to explore the coupling of depth with preservation of biosignatures. (Table 1)

Group	*Sample ID*	*Sample*	*Sample Depth*
Hveravellir Modern Active Spring System	IC160730.09.S	Vent deposit	0 cm
	IC160730.09.I	Vent deposit	4 cm
	IC160730.01.S	Mid-apron deposit	0 cm
	IC160730.01.I	Mid-apron deposit	3 cm
	IC160731.08.S	Distal apron deposit	0 cm
	IC160731.08.I1	Distal apron deposit	12 cm
	IC160731.08.I2	Distal apron deposit	18 cm
	IC160730.04.S	Pisolith layer	0 cm
Gunnuhver Modern Inactive Spring System	IC160726.06.S	Vent deposit	0 cm
	IC160726.06.I	Vent deposit	7 cm
	IC160727.02.S	Vent deposit	0 cm
	IC160727.02.I	Vent deposit	5 cm
	IC160727.05.S	Mid-apron deposit	0 cm
	IC160727.05.I	Mid-apron deposit	7 cm
	IC160727.03.S	Distal apron deposit	0 cm
	IC160727.03.I	Distal apron deposit	7 cm
Lýsuhóll Relict Spring System	IC160807.04.S	Vent deposit	0 cm
	IC160807.04.I	Vent deposit	3 cm
	IC160809.03.I	Vent deposit	2 cm
	IC160808.12.S	Vent deposit	0 cm

Table 1: Table of samples identifying which spring system they belong to as well as relative proximity to vent and depth of sample retrieved [3].

Methods: Organics analyses were performed with py-GC-MS. Gas chromatography-mass spectrometry is used because it is similar to the SAM instrument that *Curiosity* is equipped with. GC-MS along with pyrolysis can be used to detect alkanes and alkenes within the rock record. This study builds on the methods of [3] by exploring the organics yield from samples treated with space flight-like pyrolysis GC-MS.

Samples were analyzed with both flash pyrolysis (at 600°C) and SAM-like ramped pyrolysis (at 35°C/min).

Flash pyrolysis and ramped pyrolysis apply heat to extract organic hydrocarbons preserved within the silicious sinter samples. It is crucial to understand how organics may be liberated from these rock types with space flight-like techniques.

Results: Preliminary results indicate a complex mixture of alkanes and alkenes (C_9 to C_{15}) [Figure 3], and several aromatic molecules with variable methyl functional groups. Sample 160726,06,I (Figure 3) is a 7cm deep sample from the Gunnuhver vent that has one of the lowest total organic carbon of the samples in this study (0.02%) [3] although several acyclic and cyclic organic molecules are detectable using py-GCMS.

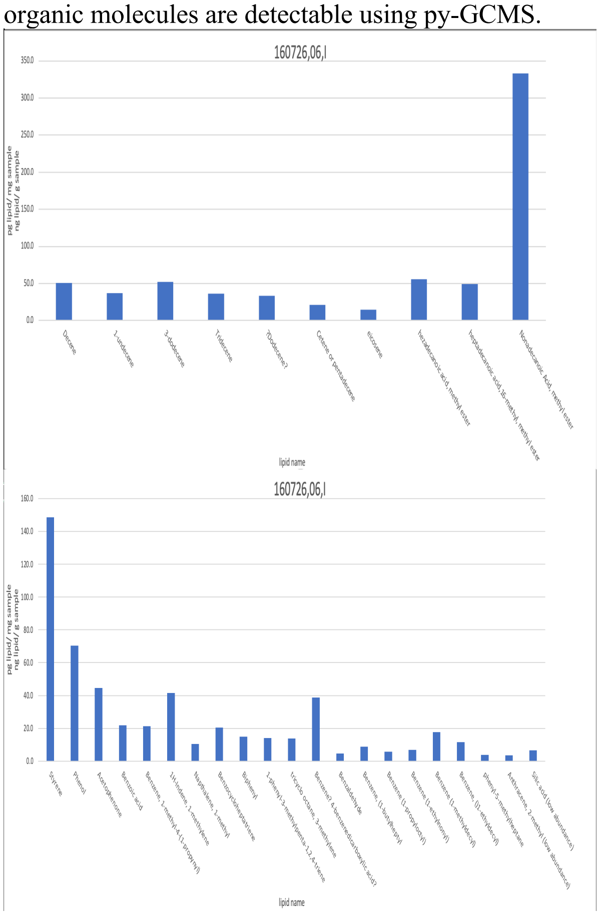

Figure 2 Graphs depicting alkanes and other organics extracted from the sinter using py-GC-MS. Shown in units pg lipid/mg sample.

Discussion: These findings reveal that alkanes and alkenes are readily detectable in both the surface and subsurface samples. Further analysis aims to determine the degradation pattern related to burial depth and sample age. Hot spring mid- to distal aprons are still geomorphologically definable in older and degraded terrestrial sinter systems and thus can be detectable on Mars from orbital satellite imagery. Biosignature preservation likely deteriorates throughout geologic time scales due to fumarole overprinting in hot and dry environments, like Gunnuhver. Fumarole overprinting is a likely experience for Mars with long lived volcanic heat and dynamic water histories. This study indicates that organics detection is possible in relatively young hot spring deposits. Rovers equipped with pyrolysis-GC-MS instruments may be able to detect organics in inactive hot spring deposits if those deposits are relatively young. Thus, landing site and selections of samples are of paramount importance while searching for organics in the surface and subsurface of Mars.

Acknowledgments: I would like to thank Dr. Amy Williams for her instruction, input, and for allowing me to be a part of the Life on the Edge lab at University of Florida. Many thanks to J.R. Skok and Kate Craft for their insights and collaboration. I would also like to thank my collaborators at Life on the Edge, an amazing team that keeps me inspired.

References: [1] Kaur G. et al. (2011) *Astrobiology.* Vol 11 259 [2] Skok J. R. et al. (2010) *Nature Geoscience* Vol 3. 838. [3] Williams A. et. al. (2021 *Astrobiology.* Vol 21. 60-66.