MARTIAN HOT SPRING DEPOSITS AS A DEPOT FOR BIOSIGNATURES (AND EXTANT LIFE?).

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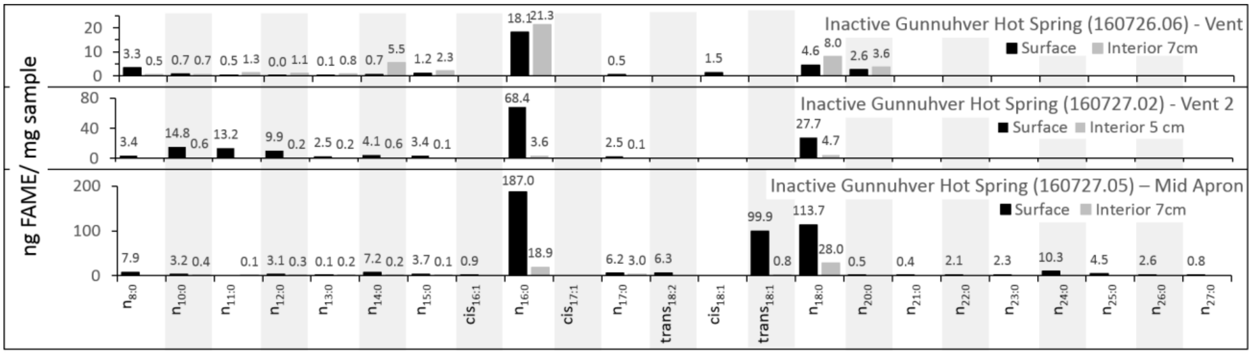

Figure 1. Abundance of fatty acids in recently inactive Iceland hot spring Gunnuhver at two vents and the spring mid-apron, at both the surface and subsurface (from 5 to 7cm depth).

Introduction: Volcanism and water on Mars likely produced habitable regions where geothermal energy interacted with the hydrosphere, presenting an ideal environment to support life on Mars, if it arose. The Nili Patera region exhibits mound morphology and silicic sinter deposits indicating past hydrothermal activity [1]. The Columbia Hills region in Gusev crater has evidence for volcanic hydrothermal environments with outcrops of opaline silica forming nodular and digitate silica structures [2]. These sinters provide potential locations to concentrate and preserve organic biosignatures that could be targets for future planetary exploration. To inform the goals of these future missions, organics preservation was explored in three **Icelandic hydrothermal sinter sites** as analogs to the **Nili Patera region**, and in digitate stromatolites from the **El Tatio geyser field** in the Chilean Atacama desert as analogs to **Columbia Hills site** in Gusev crater.

Figure 2. Cross section of El Tatio nodular stromatolite.

Methods: Samples were collected using organically clean methods from each sinter site. Icelandic site activity ranged from active (Hveravellir) with fumaroles and hot springs to recently inactive (Gunnuhver) to relict (Lysuholl). El Tatio geyser samples were collected from an actively discharging region. In the lab, samples were ground to a powder and underwent pyrolysis at a 1mg:1µL ratio with tetramethylammonium hydroxide (TMAH) to liberate and methylate fatty acids bound in phospholipids as well as free fatty acids. This process makes fatty acids volatile and detectable to GCMS. The fatty acids were analyzed by pyro-GCMS using a 500°C flash pyrolysis on a Frontier pyrolyzer and either an Agilent 7890 GC-MS or a Thermo Scientific Trace 1310 GC-MS.

Results & Discussion: This study determined that organic fatty acid biosignatures are 1) preserved in the sinters, 2) detectable with a benchtop version of the TMAH wet chemistry experiment on the Curiosity rover SAM instrument [3], and 3) resolved enough to deconvolve the microbial ecology within these sinter deposits.

Monounsaturated fatty acids were lost at depth, indicative of early diagenesis. Odd carbon number saturated FAMEs were also lost at depth, while those with even carbon number were preserved. FAMEs >C_{20} indicate input from terrestrial plants and are only found in surface samples. The presence of $C_{18:2}$ may be linked to photosynthesis in cyanobacteria or fungi and again are only in the surface samples. There is an even-over-odd carbon number preference consistent with modern bacterial community input. Our results indicate that fatty acids are preserved at depth in all Icelandic sinter samples and are detectable with a benchtop version of the SAM TMAH wet chemistry experiment. El Tatio stromatolite analyses are ongoing.

These results demonstrate the importance of sending GC-MS instruments to Mars to support continued exploration for organic biosignatures in the near surface. Shallow subsurface access is technologically feasible on Mars today, and the capability to investigate subsurface samples is vital to access organic biosignatures that are more likely to be protected and preserved in the Martian subsurface.

References: [1] Skok, J.R. (2010) *Nat. Geo., 3*, 838-841. [2] Ruff, S.W. and Farmer, J.D. (2016) *Nature Comm., 7*, 13554. [3] Williams, A.J. et al., (2019) *Astrobio., in review.*