PRESERVATION OF LIPID BIOMARKERS IN THE ATACAMA DESERT, CHILE. M. B. Wilhelm[1,2], A. F. Davila[2,3], J. E. Eigenbrode[4], M. N. Parenteau[2,3], L. L. Jahnke[2], R. E. Summons[5], X. Liu[5], A. J. Williams[4] J. J. Wray[1], [1]School of Earth & Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA (mbwilhelm@gatech.edu), [2]Space Science & Astrobiology Division, NASA Ames Research Center, Moffett Field, CA [3]SETI Institute, Mountain View, CA [4]Planetary Environments Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD [5]Dept. of Earth, Atm. & Planetary Science, Massachusetts Institute of Technology, Cambridge, MA.

Introduction: The geologically short-lived nature of the majority of molecular biomarkers presents a challenge for reconstructing potential past biologic activity on Mars. Lipid biomarkers, which have a refractory hydrocarbon backbone, are known to survive oxidative degradation and are robust indicators of microbial presence and activity in extant ecosystems and in past environments recorded billions of years ago[1]. The conditions of initial preservation (prior to lithification) are key to establishing a long-term biomarker record. Little is known of the structural and chemical stability of lipids under extreme and prolonged dryness, or under Mars-like oxidative conditions. This study seeks to understand the accumulation and preservation of lipid biomarkers in hyperarid soils in the absence of plant-driven carbon cycling processes, and the impact of oxidizing salts on their preservation.

Field Site: Samples were collected in the Atacama Desert in September 2014 from sites along a precipitation gradient[2] between the hyper-arid Yungay region (<<2 mm rainfall/yr) to Chañaral (~12 mm rainfall/yr) to the south. The Yungay region has experienced approximately 100 million years of aridity[3], and 10-15 million years of extreme aridity[4]. As a result, nitrates, sulfates, and perchlorates have accumulated in soils composed of particles deposited by wind-blown processes[5]. These soils boast some of the lowest biomass values recorded on Earth[5]. Prior studies report that no notable starvation or stress response is reflected in the phospholipid fatty acid (PFLA) distribution[6], which is unexpected given the hyper-aridity and low soil organic carbon content, and indicates that metabolic activity halted before exposure to the extreme conditions of the Yungay region.

Sampling: Samples were collected by scientists wearing cleanroom suits, masks, glasses, and gloves to minimize contamination at this stage of the process. Soils were collected with solvent cleaned tools and placed into ashed glass jars and kept frozen until returned to NASA GSFC for storage at -20º C.

Methods: For each unique sample, ~100 g of soil was pulverized with a mortar and pestle and then freeze-dried. Soils were extracted three times using a modified Bligh Dyer extraction protocol[7] in which a slurry was created using a monophasic mixture of geoclean water, methanol, dichloromethane, and soil. This mixture was separated and the resultant lipid fraction was collected and evaporated to near dryness. Medium acid methanolysis[8] and derivatization with Bis-(trimethylsilyl) trifluoroacetamide (BSTFA) was performed on the concentrated lipid fraction to ensure the detection of free fatty acids and membrane-bound fatty acids. Extracts were run on a GC-MS and peak areas quantified by comparison to an internal standard.

Preliminary Results: A number of classes of lipids were identified in the total lipid extracts of soils including fatty acid methyl esters (FAMEs), free fatty acids, primary fatty alcohols, monoalkylgycerol ethers, and plant waxes. Extracted lipid abundances were consistent with previous estimates of viable cell abundance[9]. Significant trends were observed in the abundance and diversity of lipids between surface and subsurface samples, and as a function of rainfall (Fig. 1). FAMEs were one order of magnitude less abundant in Yungay surface soils (~10-70 ng FAMEs/ g of soil) than in soils from Chañaral (~900 ng FAMEs/ g of soil). The diversity and abundance of lipids at depth points to a remarkable degree of preservation with extreme dryness and in the absence of significant biological activity. When complete, our lipid analysis will help us understand the impact of extreme dryness on soil microbial communities, and the preservation of lipid-biomarkers under Mars-like conditions.

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Figure 1: Total Fatty Acid Methyl Ester (FAME) Abundance in Atacama Soils