BIOMOLECULAR PRESERVATION IN SUBSURFACE SOILS OF THE HYPERARID ATACAMA DESERT. M. B. Wilhelm[1], D. Carrizo[2], A. Davila[1], V. Parro[2], M. García-Villadangos[2], Y. Blanco[2], C. Stoker[1], B. Glass[1]; [1]NASA Ames Research Center, MS 245-3, Moffett Field CA 94035 (marybeth.wilhelm@nasa.gov), [2]Centro de Astrobiología (INTA-CSIC), Ctra de Torrejón a Ajalvir, km 428850 Torrejón de Ardoz, Madrid.

Introduction: The hyperarid core of the Atacama Desert in northern Chile is one of the driest regions on Earth. The absolute absence of liquid water in timescales of decades, coupled to environmental stresses such as ultraoligotophy, high UV radiation and large temperature fluctuations make it an ideal place to study physiological adaptations to environmental extremes, and to explore the environmental limits of biological activity. The extreme and prolonged dryness in soils is also conducive to excellent preservation of molecular biosignatures [1], which and can be used for paleoenvironmental reconstruction, and for the development and testing of life detection strategies and technologies. Here we show a broad data set of molecular, geochemical and environmental data collected in a soil profile that expands 10^5-10^6 years in the Yungay region of the Atacama Desert. Collectively, the dataset points to a significant change in local environmental conditions over the last several million years.

Study Site: The Yungay region of the Atacama Desert experiences <2 mm of precipitation annually [2], with rain events often interspaced by a decade or more. The extreme aridity causes an absolute lack of habitation by plants and animals and contains only a sparse microbial population in surface soils that are primarily derived from atmospheric inputs [3]. We sampled a stratigraphic sequence in a soil pit that can be generally divided into three major units: gypsiferous soils in the top 90 cm, clay-rich units below 90 cm depth, and a 10 cm thick well-cemented, massive halite unit that interrupts the clay units at about 150 cm depth and acts as an aquiclude. Sparse plant material is found in the clay units below the massive halite layer [3].

Analytical approach: Soil and subsurface samples were collected at different depths by scientists wearing cleanroom suits to minimize anthropogenic contamination during sampling. Laboratory analyses included protein extraction and concentration estimation, fatty acid analysis, immunoassays with a Life Detector Chip [4], and stable istotopes (S,C,O).

Results: Preliminary work based on the lipid and hydrocarbon content of the samples showed a remarkable degree of lipid biomarker preservation even in the oldest soils analyzed (c.a. 2 Myr old) indicating that typical diagenetic processes of lipid destruction are arrested under extreme dryness [1]. Immunoprofiling with LDChip showed a siginificant abundance and diversity of well-preserved biopolymers, or molecular fragments, in samples of the halite unit and the underlying clay-rich unit, but immunoresponse was close to background levels throughout the upper gypsiferous unit (Figure 1). However, exhaustive protein extraction and proteomic analyses showed that all samples contained approximately 15-20 µgr of proteins or peptides per gram of soil. Stable isotope analyses for carbonates ($\delta^{13}C$ from -3 to -0.2‰ and $\delta^{18}O$ from -10.5 to -6.8‰) showed in situ formation at isotopic equilibrium with pure atmospheric CO_2, for the surface sediments and an increasing trend of detrital origin with increasing depth, with no evidence of plant CO_2 contribution at any depth. Meanwhile $\delta^{34}S$ (-3.7 to 3.5‰) and $\delta^{18}O$ (6- to 10‰) values from sulphate shows a clear weathering origin, with a depleted trend in the heavier isotope with depth.

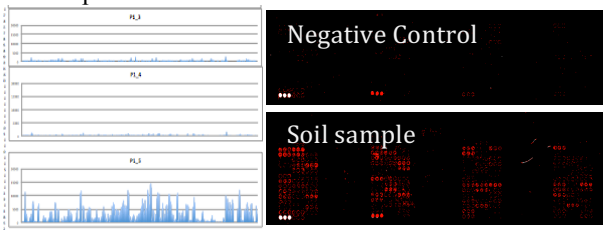

Figure 1. *Left*. Immunograms of pit soil samples showing relative abundance and diversity of biopolymers, or molecular fragments with depth. *Right*. Images of the LDChip showing lack of positive immunoassays in the negative control, and multiple positive immunoassays from soil sample.

Discussion: Preliminary results support previous conclusions that extreme dryness leads to an exceptional quality of structural and chemical preservation in at least two major types of biomolecules (fatty acids and proteins or peptides). The differences observed in biomarker abundance and degree of preservation in the differening soil units could be due to a number of factors including: interactions occurring in the mineral matrix, differences in abundance and diversity of the biological sources, and differences in environmental conditions at the time of biomarker deposition. The chemical and structural integrity of biomarkers preserved in the oldest soil horizons analyzed, together with geochemical indicators, allows for taxonomic and environmental reconstructions.

References: [1] Wilhelm M. B. et al. (2017) *Organic Geochemistry, 103,* 97–104. [2] McKay C. et al. (2003) *Astrobiology, 3,* 393-406. [3] Ewing S. et al. (2006) *Geochem. Chosmochim. Acta, 70,* 5293–5322. [4] Parro V. et al., (2011) *Astrobiology*, *11*, 969-996.

Funded by: NASA ARADS project 14-PSTAR142-0032, Spanish MINECO No. ESP2015-69540-R.