Constraints on the Metabolic Activity of Microorganisms in Atacama Surface Soils Inferred from Refractory Biomarkers: Implications for Martian Habitability and Biomarker Detection

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Dryness is one of the main environmental challenges to microbial survival. Understanding the threshold of mi- crobial tolerance to extreme dryness is relevant to better constrain the environmental limits of life on Earth and critically evaluate long-term habitability models of Mars. Biomolecular proxies for microbial adaptation and growth were measured in Mars-like hyperarid surface soils in the Atacama Desert that experience only a few millimeters of precipitation per decade, and in biologically active soils a few hundred kilometers away that experience two- to fivefold more precipitation. Diversity and abundance of lipids and other biomolecules decreased with increasing dryness. Cyclopropane fatty acids (CFAs), which are indicative of adaptive response to environmental stress and growth in bacteria, were only detected in the wetter surface soils. The ratio of trans to cis isomers of an unsaturated fatty acid, another bacterial stress indicator, decreased with increasingly dry conditions. Aspartic acid racemization ratios increased from 0.01 in the wetter soils to 0.1 in the driest soils, which is indicative of racemization rates comparable to de novo biosynthesis over long timescales (*10,000 years). The content and integrity of stress proteins profiled by immunoassays were additional indicators that biomass in the driest soils is sin situ microbial growth in the driest surface soils of the Atacama, and any metabolic activity is likely to be basal for cellular repair and maintenance only. Our data add to a growing body of evidence that the driest Atacama surface soils represent a threshold for long-term habitability (i.e., growth and reproduction). These results place constraints on the potential for extant life on the surface of Mars, which is 100–1000 times drier than the driest regions in the Atacama. !