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Ecosystem Genomics minor

## **Water as a driver of soil microbial diversity in high elevation, hyper-arid volcanic system in the Andes, northern Chile**

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### **Abstract**

The Andean volcanoes of the Atacama Desert encompass extreme environments that present unique opportunities to explore factors shaping the ecological and metabolic capacity of living organisms. Extreme conditions in this region include diurnal freeze-thaw cycles, low oxygen pressure, high radiation, limited organic carbon and nitrogen, a thin atmosphere, high metal abundance, and scarce water. As part of a study to elucidate rules of life, we are examining factors that shape microbial communities at the interface of water availability and elevation in such hyper-arid and polyextreme environments. At Llullaillaco Volcano, Chile, we collected soils

with and without evidence of liquid water at 200 m intervals along an elevation gradient that spanned 3000 to 5200 m above sea level (masl). Soils were characterized via metabarcoding (Illumina) and metabolomics (Liquid Chromatography Mass Spectrometry; LC-MS/MS, including both hydrophilic interaction liquid chromatography (HILIC) and reverse-phase (RP) liquid chromatography). We predicted that (1) microbial and metabolomic richness would vary negatively with elevation and positively with liquid water, (2) ecological strategies would shift to autotrophic and chemolithotrophic dominance at higher elevations, compared to chemoorganotrophs at lower elevations. Our preliminary results show that bacterial and fungal communities vary markedly and non-monotonically in composition, function, and metabolome expression as a function of elevation and water conditions. Actinobacteria and a basidiomycetous yeast (*Naganishia*), which exhibit dormancy and other mechanisms to tolerate poly-extreme conditions, dominate higher elevation sites. Their metabolomes reveal distinctive metabolites not yet detected in more mesic environments. Functional shifts in microbial communities highlight ecological strategies to establish and persist in high volcanic environments. Together, our results highlight the heterogeneity, convergence, and novelty of high-elevation soil microbes and their metabolomes, providing an opportunity to link microbial community dynamics with functional outputs in an area of Earth that most resembles known exoplanet systems – the foundations for understanding rules of life on this planet and beyond.