Antarctic Dry Valleys melt water systems analogues of Martian gullies: characterization of microbial communities and soil properties

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Abstract

Antarctic McMurdo Dry Valleys (MDVs) are characterized by extremely low temperatures, strong desiccating winds, very low precipitation, aridity, high solar irradiation, and locally high salt concentrations. The majority of the MDVs surface is unconsolidated sediment, with an ice-cemented permafrost with neither wet nor dry active layers, as soil temperature generally never rises above 0 ∘C. For these characteristics, these soils are regarded as one of the closest terrestrial analogues of the cold arid Martian regolith.

Despite cold and dry conditions, gullies and streams occur in a broad zone distal to the ephemeral streams, as dark bands, commonly on north-facing slopes, from surface top-down melting of snow and ice, due to enhanced summer solar insolation. They host a biological activity that can persist even after surface water flow in the channel has ceased, surviving long periods of desiccation and extreme cold in a cryptobiotic state. MDVs hydrological system may provide important insights into the potential configuration of Mars climate, in which MDV-like ephemeral streams and rivers could have originated through processes related to the presence of liquid water in the recent geological past and could have hosted life forms remained trapped within the gully (Levy et al., 2012). NASA has chosen Jezero Crater as the landing site for Mars 2020 rover mission, as it is located on the western edge

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of Isidis Planitia, a giant basin, once home of a river delta. This area could have preserved organic molecules and other potential signs of a hypothetical microbial life from the water and sediments that flowed into the crater billions of years ago.

During the XXXI (2015/16) Italian Antarctic expedition, soil samples have been collected in MDVs, in the areas surrounding three Antarctic lakes, namely Lake Fryxell, Lake Hoare and Lake Joyce. Although soil communities of these areas have already been deeply studied, here we propose a new multidisciplinary approach that could lead to characterize the microbiota and the environmental conditions determining the colonization in such limiting environment, and to provide parameters that could be uniquely descriptive of the presence and the type of colonization. To achieve these goals, both fungal and bacterial diversity have been characterized via metabarcoding next-generation sequencing. In these samples, we found 21987 and 292 OTUs for Bacteria and Fungi, respectively, with richness ranging from 2962 to 4859 OTUs and from 7 and 122 OTUs, respectively. Main bacterial phyla within Lake Hoare and Lake Joyce communities were Bacteroidetes and Firmicutes (accounting for $> 80\%$ of the relative abundance), whereas, Lake Fryxell samples showed 27% Cyanobacteria and 3% Deinococcus-Thermus, that were nearly absent in the other two sites. For fungal communities, we highlighted a dominance of saprotrophic and lichen forming organisms in all samples. Soil edaphic parameters (pH, relative moisture, C, N, P, Na, K, Mg and Ca content and cation exchange capacity) and granulometry have been characterized and were related to the diversity and composition of microbial communities. Laser induced fluorescence spectra were also acquired *in situ* by using an in-house developed instrument to detect accessory pigments and contribute to the characterization of soil communities. Additionally, the DRIFT (Diffuse Reflectance Infrared Spectroscopy) spectra and colorimetric data have been recorded for soil samples, in order to be associated to specific communities and edaphic characteristics. In this view, our data could be of interest for future Martian explorations, focused on the search of signs of past or present life forms, as they could describe composition, soil parameters or specific color spectra that could be descriptive of living or extinct biological colonization.

Levy, J. (2012). Icarus, 219(1), 1-4.