A COMPARISON BETWEEN THREE PROJECTS EXPLORING HOW LIFE MIGHT ORIGIN AND PERPETUATE ON MARS USING PLANETARY FIELD ANALOGUES.

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The Italian Space Agency (ASI) has promoted the definition of a national long-term Astrobiology Roadmap, a common platform for the scientific communities working on different topics with the goal of generating synergies and identify future opportunities for joint activities. The Roadmap identifies specific areas of interest for the community, including the Planetary Field Analogues (PFA) which are considered hot topic for the understanding of where and how life (as we know it) may exist and evolve, how we can search life beyond the Earth and how to prepare future exploration missions. Given that, ASI selected and funded three-years projects, ASTERIA, CRYPTOMARS, and HELENA, which aim at exploring the origin of life, evolution and habitability in PFA by combining approach of planetary science, geology and microbiology.

In CRYPTOMARS the genetic and functional characteristics which would allow a microbial community to resist, adapt, spread and perpetuate itself on Mars or on Mars-like planets will be studied. During the project, a wide range of selected rocks, hosting a cryptoendolithic communities, from ice-free cold areas in continental Antarctica will be exposed to different physical and climatic stresses, such as UV and ionizing agents, dehydration and extreme temperatures, simulating past and present Martian environments. The survival responses of these microbial communities will be then investigated, by using a metabolomic and lipidomic approach. The resulting data will be then integrated with those obtained in a previous campaign to better understand the genetic and metabolic specific pathways involved in the resistance and survival of the cryptoendolithic communities. The ASTERIA project will investigate the adaptive potential of cyanobacteria, which were isolated from environments characterized by low light conditions enriched in far-red/infrared, to stellar ultraviolet radiation (UVR) through a multidisciplinary approach based on laboratory simulations and theoretical models. Cyanobacterial growth and survival limits will be examined after exposure to UVR, while the adaptability of the most resistant isolates will be tested through laboratory simulations of paleo planetary environmental conditions. Additionally, their photosynthetic activity will be monitored in real time during exposure to simulated solar and M-star spectra, in the presence of UVR, while cellular survival will be tracked using miniaturized experiment units. Omics techniques, including transcriptomics and comparative genomics, will be employed to identify resistance mechanisms under simulated conditions, including photoprotection mechanisms such as UV-protective pigments and DNA repair systems. Finally, the main goal of HELENA project is to characterize the extreme and polyextreme habitats of Lake Bagno dell'Acqua (LBA), which is placed in the Pantelleria Island National Park in Sicily, from an astrobiology prospective. The project focuses on the analysis of potentially inherited structures in the fossil record and on the presence of accumulations of phosphate, considered a biogenic element of extreme importance in astrobiology and for the origin of life, on the sediments and surfaces of the lake.

Besides the common thematic of PFA study, the three projects could benefit from synergies and sharing of methods and results. In ASTERIA and CRYPTOMARS, the growth, resistance and adaptability of the microorganisms, which were isolated in extreme habitats, will be studied in a dedicated chamber simulating the conditions (past and present) on Mars-like environments. The operational parameters will be selected on the basis of modelling studies on planetary climate and atmosphere, while the genetic and metabolic response to stresses derived from UV radiation will be investigated by molecular tools. While in CRYPTOMARS and ASTERIA one of the main objectives is to develop and validate a realistic model of the adaptability of microbes in environmental Mars-like conditions following laboratory and computational tests, in HELENA a model will be developed on the basis of the actual physicochemical characteristics of the bedrock and water columns of the vulcanic Sicilian target. The final models of the three projects will also describe the interactions between the microbial community structure and geochemical composition of the environment. As a matter of fact, a comparison of response to physical stresses as well as of substrate and habitat in terms of differences between cold arid deserts (CRYPTOMARS), hydrothermal vents (ASTERIA), volcanic lakes (HELENA) will be carried out in a synergy between worldwide reputed researchers and academics and the ASI project managers and scientists. The findings of these three projects will help in the definition of the boundary conditions under which life can thrive on Earth’s environments and compare them to the conditions observed on other planetary bodies with the ultimate aim of revealing and discussing whether life could originate, evolve, or survive elsewhere in our Solar System.