THE POTENTIAL OF DECEPTION ISLAND (ANTARCTICA) AS A MARTIAN ANALOGUE OF ASTROBIOLOGICAL INTEREST. M. A. Leal1,2,3,7, D. Tovar1,2,3,6, M.A. de Pablo2, M.A. Bonilla4,5, G. Leone5, N. Tchegeiaкова1,6, J. Sánchez1,7, A. Molina6, J. San Martín9 – 1Planetary Sciences and Astrobiology GCPC Research Group, Universidad Nacional de Colombia, Colombia and Corporación Científica Laguna. (maleal@unal.edu.co/ angelica.leal@edu.uah.es) 2Unidad de Geología. Universidad de Alcalá, Spain. 3Associated researcher of Colombian Antarctic Program, Colombian Commission of the Ocean, Colombia. 4Biology of Tropical Organisms Research Group, Universidad Nacional de Colombia, Colombia. 5Institute for Research in Astronomy and Planetary Sciences, Universidad de Atacama, Chile. 6Departamento de Geociencias, Facultad de Ciencias, Universidad Nacional de Colombia, Colombia. 7Departamento de Biología, Facultad de Ciencias, Universidad Nacional de Colombia, Colombia. 8Department of Planetology and Habitability, Centro de Astrobiología, CAB (CSIC/INTA) Spain. 9Technische Universität Bergakademie Freiberg, Germany.

Introduction: Astrobiology is considered an interdisciplinary field that seeks to unravel the emergence and evolution of life on Earth and explore the potential for life beyond it. Terrestrial analogs are a well-known method in Astrobiology to assess the habitability potential. These analogs are classified into field and laboratory categories [1]. Field analogs, exemplified by extreme terrestrial environments, facilitate diverse research endeavors, from geological processes on other bodies to instrument testing for space missions [2]. Laboratory analogs, on the other hand, simulate extraterrestrial conditions, contributing to the understanding of biological adaptations and survival mechanisms [1].

A classification was proposed by Foucher and collaborators distinguishing analog sites and samples for planetary exploration, such as the functionality of each one [3]. Over thirty analog sites, predominantly Mars analogs, have been identified on Earth [1]. Extreme environments are prioritized in astrobiological research, offering insights into life’s adaptability under adverse conditions. Antarctica, with its harsh conditions, particularly the McMurdo dry valleys, emerges as a valuable analog for Mars due to climatic similarities [4].

Specifically, three Antarctic locations—McMurdo Dry Valleys, Victoria Land Mountains, and Lake Vostok—have been identified as analog sites [5]. McMurdo, the driest and coldest place on Earth, resembles Mars’ conditions. Victoria Land’s high altitude exposes microorganisms to increased UV radiation. With its subglacial lake akin to Enceladus or Europa, Lake Vostok presents unique astrobiological potential.

Here we focus on further exploration of Deception Island, Antarctica, to evaluate its characteristics as analog [6]. The volcanic island, which features diverse magmas, has been studied for its geomorphological similarities with those found on Mars and its logistic facilities [7,8]. However, a comprehensive analysis of its astrobiological relevant features is still lacking. This research aims to bridge this gap, reviewing Mars’ characteristics and delving into Deception Island’s attributes. This endeavor seeks to establish Deception Island as a promising multifunctional analog for Mars, offering new perspectives and opportunities for astrobiological research.

Methodology: For the evaluation of Deception Island as a multifunctional analogue, four methodological blocks of evaluation were proposed: 1) geology and geochemistry, 2) geomicrobiology, 3) geomorphology, and 4) manned missions. Some phases have been already developed:

Sampling of rocks and pyroclastic material: Two samples were taken during the VIII and IX Colombian expeditions to Antarctica (2021-2022/2022-2023) in collaboration with the Spanish Polar Committee, the personnel of the Spanish Antarctic Station “Gabriel de Castilla” (SAS-GdC), the Spanish Army, and the Spanish Navy, collecting samples at different sites in the island.

Characterization of temperature profiles in geothermal anomalies: Considering the geological context [9] and field observations, transects of between 500 and 900 m length were made, in which temperature measurements were taken every 10 m (Figure 1). In addition, temperature measurements were taken every 10 m in the profiles, finding temperature anomalies (Figure 1). In addition, the hottest point was selected in the profiles with temperatures exceeding 60°C, and the material was sampled for microbial community analysis.

Fig. 1: Location map of the Temperature Transect Zones on Deception Island and range of measured temperatures.
Cultivation of endolithic bacteria with plant growth promoting activity: Each rock sample was processed in a laminar flow cabinet and drilled with sterile drills, to cultivate the interior material in R2A medium at 10°C under anaerobic conditions. Subsequently, those microorganisms that could be cultured were subjected to a qualitative evaluation of nitrogen fixation and phosphate solubilization.

Manned missions: To evaluate Antarctic Stations as infrastructures for developing analog missions, a self-perception instrument was constructed based on the parameters recognized by Clément and Reschke [10]. Also, we took daily measurements in the morning and afternoon of temperature, humidity, and carbon dioxide parameters indoors for one month in the confined space of the Spanish Antarctic Station “Gabriel de Castilla (Figure 2)”

Results and conclusions: 19 points on the island were sampled for geological and geomicrobiological analysis. Five zones of thermal anomalies were measured, with the highest temperature peaks found in the fumaroles sector at 100.1°C. However, it was in the Kroner Lake sector where microbial mats were evident (Figure 3), whose colorations varied as a function of temperature and pH. Five morphotypes were obtained from the analysis of endolithic microorganisms and are being evaluated in nitrogen-free medium and phosphate solubilization medium.

Regarding the evaluation of manned analog mission parameters, it was preliminarily observed that the most influential factors at the SAS-GdC were the lack of personal space, sudden temperature changes, and work overload.

Considering the above, preliminary results allow us to continue evaluating the Deception Island hypothesis as a multifunctional analogue of Mars, with astrobiological interest. Highlighting the isolation and temperature factors for developing analog missions, the aspects of temperature change, and confinement for using facilities as analog bases. Volcanic characteristics, as a mineralogical analogue of the Martian and/or lunar surface. And finally, the presence of microbial mats and endolithic microorganisms as potential models for astrobiology on present-day and past Mars.

Fig. 2: Spanish Antarctic Station “Gabriel de Castilla” as a space for the development of analog missions.

Fig. 3: Picture of the Kroner Lake Microbial Mats, a spot of high interest as an astrobiological analog for Mars.

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