EXTREME HABITAT OF VOLCANIC LAKES FOR THE ASTROBIOLOGICAL EXPLORATION (HELENA) B. Cavalazzi[1], M. Pondrelli[2], L. Zucconi[3], G. Pecoraino[4], F. Lucchi[1], A. Maris[1], L. Marinangeli[5], F. Canini[3], C. Ripa[3], A. Cassaro[1], D. Rouwet[6], M. Bellucci[7], C. Pacelli[7], L. Sandri[6], G. Tamburello[6] [1]CIRI Aerospaziale - Univ. Bologna (barbara.cavalazzi@unibo.it), [2]IRSPS-Univ. d'Annunzio, Pescara, [3]Dip. Scienze Ecologiche e Biologiche - Univ. della Tuscia - Viterbo, [4]INGV-Sezione di Palermo, [5]Univ. d'Annunzio, Chieti, [6]INGV-Sezione di Bologna [7]ASI – Roma.

Introduction: The search for signs of life on other planets is one of the main drivers of the ongoing planetary exploration (i.e. NASA Mars 2020 and ESA ExoMars). Further activities related to the handling of planetary samples from future missions require the definition of protocols for the *Sample Receiving Facility* (SRF) and MSR *Curation Activities.*

To better define sample collection strategies and the associated geological environments, Space Agencies have recognized the crucial importance of identifying Planetary Field Analogues (PFAs) and Laboratory Analogues (LAs) techniques to develop correct sample acquisition routes and test instrument prototypes.

The study of PFAs, i.e. natural terrestrial environments considered representative of geological contexts and processes (both active or fossilized) as well as extraterrestrial environmental conditions, plays a crucial role in characterizing the extreme physical and chemical conditions where life could arise.

Furthermore, the comprehensive study of different analogue sites provides the opportunity for a better understanding of the nature of life and its adaptation strategies by studying the traces (biosignatures) that it is capable of producing and leaving as fossil evidence in the environments that once hosted them (=preservation potential).

The project: The goal of the HELENA project is to characterize, from an astrobiological perspective, the Bagno dell'Acqua lake (BAL) on the island of Pantelleria in Sicily. BAL is a lake hosted along the border of a volcanic caldera and characterized by hydrothermal activity. Moreover, it is associated with peculiar polyextreme environmental conditions, such as an arid climate and intense seasonal evaporation, high thermal water temperatures, pH ranging from slightly acidic to strongly alkaline, high salinity expected as a consequence of evaporation, and probably concentrations of metals or other chemical elements due to the interaction of the water with volcanic products (rocks, gases, thermal fluids). The special BAL's features will be studied by a pool of geologists, planetary geologists, microbiologists, mineralists, volcanologists and geochemists. An environmental context of this type will support a complex and polyextreme ecosystem of certain interest for astrobiology. Such a study will expand our knowledge of the diversity and limits of the growth and survival of life as we know it. The study of biosignatures and mineral-microbe interactions is made even more interesting by the fact that the terraced structure of the borders of BAL preserves portions of the paleo-lake before the lake's water table level lowered to its current position. This will allow for a comparative study of (sub)fossil counterparts, thus verifying the potential for the preservation of biosignatures in this type of environment overt time.

Finally, the BAL, which is subjected to evaporation cycles, could be the perfect analogue for a better understanding of primordial, if not even prebiotic, habitats: it seems that the accumulation of phosphates along the coasts of primordial alkaline lakes, due to evaporation cycles, could be the process facilitating the origin of life [1]. The BAL provides a unique opportunity to investigate and test some aspects of this recent but fascinating hypothesis about the origin of the first terrestrial habitats, through studies on recently accumulated phosphates and (sub)fossils (associated with terraced surfaces), both directly on the ground and in the laboratory (PFA and LA).

Moreover, the BAL seems to have a geological context comparable to several Martian fossil basins, thus favouring a comparative geological and compositional analysis, finalized at bridging the scale-gaps between the two settings and develop a methodological, scientific, and conceptual protocol in the framework of future robotic and/or manned missions.

This 36-months project has been recently funded by the Italian Space Agency (contract n. 2023-9-U.0) and Barbara Cavalazzi (CIRI- Univ. of Bologna) is the PI. Other partners are: Univ. Chieti-Pescara, team leader M. Pondrelli; Univ. Tuscia, team leader L. Zucconi; INGV-Palermo, team leader G. Pecoraino.

The HELENA project was conceived as an interdisciplinary and multidisciplinary project, integrating the complementary skills of all team members. All members of the team, coming from different geographical areas, have consolidated experience in astrobiology and in the different scientific topics involved in this proposal. By working synergistically, the team will help to address future science and exploration challenges.

Field activities will be planned in collaboration of the National Park of Pantelleria Island.

References: [1] Toner and Catling (2020) *Proceedings of the National Academy of Sciences*, *117*