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ESTABLISHMENT OF A MARS ANALOGUE RESEARCH STATION IN PAMPAS DE LA JOYA (ATACAMA DESERT IN SOUTHERN PERU)

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ABSTRACT

Human race's thirst for knowledge boosted by curiosity has led us to achieve great technological advances and overcome goals that were once thought impossible. Today's goal is to colonize the Red Planet and make human exploration on Mars a reality. The main objective of the Mars Analogue Research Station (MARS) program of The Mars Society is to investigate the operational environment of a base on Mars, through simulations of how it would be like to live and work on Mars-like environments on Earth. Currently, The Mars Society operates two analogue bases: Flashline Mars Arctic Research Station (FMARS) and Mars Desert Research Station (MDRS). These receive researchers from various disciplines (e.g., physics, biology, astrobiology, geology, engineering, etc.) who carry out research aiming to make life viable on Mars. Crew 126 (Team Peru) of MDRS has formed The Mars Society Peru as an official branch of The Mars Society, aiming primarily to build and establish a MARS in southern Peru. This paper presents the location, design and benefits of the proposed base. The selection of the location is the desert of Pampas de la Joya, in the department of Arequipa in southern Peru. This choice was based on the work of Dr. Julio Valdivia Silva, Ph.D. in Astrobiology, who works at NASA Ames Research Center. His work [1] sustains that the area called ¨Mar de Cuarzo¨ or Sea of Quartz in the desert of Pampas de la Joya between 16ºS and 17ºS has the characteristics needed to be a new Mars Analogue: hyper-arid area, low organic matter concentration, extreme environmental conditions, very low levels of microorganisms and Martian-like geomorphological features. The design of the station has innovations that will make it different from the existing Mars Society bases. This base will serve as a research center that will house professionals and students from around the world to do research related to Mars, with the objective of placing individuals on the Martian surface.

1. INTRODUCTION

Sending people to Mars is the next giant leap for humanity and today's efforts should be oriented in colonizing the Red Planet and making human exploration on Mars a reality. In order to prepare for future manned missions on Mars, it is necessary to simulate the conditions in Mars-like environments here on Earth and perform experimental analysis on these soils. These places provide a better understanding of the geological, geochemical, and microbiological processes that could have occurred on the Red Planet [1]. These soils are also ideal to test the rovers and unmanned aerial vehicles (UAVs) that will be sent to Mars before its mission to guarantee its success.

The Mars Society has located two places that have similar characteristics to the Martian soils. There, Mars Analogue Research Stations have been built where simulations of the operational environment of a base on Mars take place. The crews inside these stations live and work as if they were really on Mars. The most important analogue stations are Flashline Mars Arctic Research Station (FMARS) [a] in Devon Island, Canada, and Mars Desert Research Station (MDRS) [b] in Utah, USA.

Only two stations in the whole world that simulate the Martian conditions are not enough for all the investigators around the globe who want to test their projects related to Mars. This is the reason why it is important to find another Mars-like environment on Earth that can receive these researchers and, most importantly, that can be a truly simulation of the Red Planet, so that the crewmembers feel that they were living in an early Mars habitat. This Mars-like environment is Pampas de la Joya Desert, in southern Peru.

2. MARS ANALOGUE RESEARCH STATIONS

The Mars Analogue Research Stations are places to develop and test protocols, procedures, tools and equipment in similar conditions that the future first human Mars explorers will encounter. Their environments provide the crewmembers an opportunity to overcome technical and psychological challenges by developing new solutions and testing them. Only through this experience, we will be able to know what is critical for human safety and productivity on the surface of Mars. In these Mars-like environments, The Mars Society launches a program of long-duration geology and biology field exploration operations conducted under the same constraints as they would on the Red Planet in order to start learning how to explore on Mars [3].

2.1 Flashline Mars Arctic Research Station (FMARS)

FMARS is located in Nunavut, Devon Island, Canada. Its coordinates are approximately 75° 25′ 52.75″ N, 89° 49′ 24.19″ W. The station is situated on Haynes Ridge, which is a 23 km diameter crater formed approximately 39 million years ago [3].

Mars is a cold place with average temperatures below freezing, ranging from approximately -150 °C to 20 °C. Precipitation is very slight in Mars due to the low atmospheric pressure, which is 1% of Earth's. The environment on Earth that best matches these specific conditions on Mars is the polar desert located in the Arctic and Antarctic regions. The temperatures there vary from about -30 °C to 10 °C and the average precipitation is less than 250 millimeters, reason why there is very little vegetation. Another Mars-like characteristic found in this analog is a geomorphic feature, the permafrost [3].

2.2 Mars Desert Research Station (MDRS)

MDRS is located in the Mojave Desert. Utah, USA, approximately 12km northwest of Hanksville.

Mars is a hyper-arid place. Precipitation is very slight in Mars due to the low atmospheric pressure. The environment on Earth that is a good match to these specific conditions on Mars is the Mojave Desert in Utah. This is a region with geomorphological features similar to Mars.

3. LOCATION OF THE STATION

A Mars-like environment on Earth is defined by the distribution of living organisms, by the organic matter and by the chemical properties of the soil. [1] If it is chosen properly, it will guide the investigation of possible habitable environments on Mars. An analog to Mars of great scientific interest is the Atacama Desert, located in South America, between northern Chile and southern Peru [c]. This place has been studied by many researchers who have published very interesting works such as [1], [2], [5] and [6]. This desert lies on the west slopes of the central Andes between 15°S and 30°S, at elevations between sea level and 3500 m.a.s.l. The Atacama Desert stands as the driest region on earth, it is a place where rain is virtually absent and where there are no evidence of vestiges of life [1]. The northern continuation of the Atacama Desert is represented by Pampas de La Joya Desert in southern Peru.

Pampas de la Joya Desert is located between the departments of Arequipa and Moquegua in the south of Peru. The area of interest is near the city of La Joya in the department of Arequipa [d].

For the location of the station we have chosen this place based on [1] and [2], where it is sustained that the area known informally as ¨Mar de Cuarzo¨ or Sea of Quartz in Pampas de la Joya Desert has the characteristics needed to be a new Mars Analogue. Its soils contain very low levels of organic matter, there is absence of microscopic life, presence of iron oxides and it presents landscapes similar to various regions on Mars.

3.1 Sea of Quartz

The exact coordinates of Pampas de la Joya Desert are: 16º30’ S – 17º S, 72º30’ W – 71º30’ W. It is surrounded on the southeast by the Tambo River, on the northwest by the Camaná River, on the northeast by the Andean foothills and on the southwest by Cordillera de La Costa [e].

In [1], Sea of Quartz is defined in a rectangular area of 114 km long and 60 km wide elevated to an average height of 1200 m.a.s.l. [f]. The study in [1] took place between 2004 and 2008, during which different locations were studied, but the most interesting one was “Sea of Quartz” which is located at 1140 m.a.l.s. on the following coordinates: 16 44.5560ªS 72 02.5830ªW. According to studies made in [1], Sea of Quartz is a Mars- like environment because of the following reasons:

-It is a hyper-arid area since its Aridity Index, calculated as the ratio evapotranspiration/ precipitation, is below 0.05 [g].

-It has low concentration of organic matter, less than 20 ppm of organic C, not far from the results of the Viking, which are 0.7 to 6.5 ppm of organic C on Mars.

-It has high oxidant activity due to the presence of microclimates and the influence of the “El Niño Southern Oscillation” – this is a climatic phenomenon that causes intense rains in the Pacific shores of SouthAmerica - which allowed the formation of chemical deposits in these soils such as iron oxides which gives the red color to the soil.

-It has extreme environmental conditions due to the absence of rain and low levels of humidity of the air and soil.

-It has very low levels of microorganisms.
-It has Martian-like geomorphological features.

According to the environmental data in Sea of Quartz [h], temperature profiles are neither extremely hot, nor cold. The maximum air temperature recorded was 35.9°C, and the minimum was 4.5°C. The monthly mean temperatures do not change much year-to-year. On the contrary, the humidity of the air and of the soil are highly variable. The absence of rain in Pampas de la Joya causes soil humidity to drop below 30%, which is extremely dry for soil. This value of moisture does not allow the growth of any type of vegetation. The study [1] also shows that soils that form Pampas de La Joya are coarse regoliths with accumulation of large fragments of white quartz.

4. DESIGN OF THE STATION

The design of the station is in early stages. Primarily, the habitat will be trimodular. The modules will be fuselages of planes donated by the Peruvian Air Force (FAP). In this way, the costs of building the station will be strongly diminished.

La Joya station will have 2 floors. The first floor will correspond to the working area and the laboratory, for that reason it will need to be equipped with the necessary tools for investigation (mechanical tools, electronic components, geological and biological tools, microscopes, refrigerator for samples). This floor will have two air locks for the simulated astronauts to step outside the base, an exercise area -new space that is not present in the existing Mars Society stations-, a toilet room, a shower room and an EVA room to store the suits. The second floor will have six bedrooms for the explorers to sleep. On this floor, there will also be a kitchen, a refrigerator, food pantries and a dining table. This floor will also have a work zone where the researchers will write their reports.

4.1 GreenHab

In future missions to Mars, space ships will not carry tons of food and water, since space and weight are critical parameters in their design. For that reason, the Mars explorers should be able to build and maintain a greenhouse where they will cultivate plants for their food. The station in La Joya will have a greenhouse which will contain a variety of plants in which the Peruvian quinoa will be included because it has a very high nutritional value since it contains lots of proteins and has been already used in NASA missions.

5. PARTNERSHIPS

We believe that the estimate cost to establish and equip the station will be $230,000. The Mars Society Peru is currently in conversations with several important universities in Peru in order to start working on researches that could be tested in this station and the possibility of them donating science instruments to equip the base. The Peruvian Space Agency, CONIDA, will provide the technical and human support in the areas of physics, geology and astronomy. The site for the station is located near a military base of the FAP. The FAP will provide:

-The airport of La Joya military base for the transportation of the crewmembers between the capital of Peru, Lima, and La Joya.
-Military security of the zone in order to guarantee the safety of the crew and of the station.
-A hospital with medical staff in case of any accident of a crewmember.
-Buildings for the crews to stay the nights before and after the rotation.

6. CONCLUSIONS

In conclusion, Sea of Quartz is a very interesting place in Pampas de La Joya desert to establish a Mars Analogue Research Station. This area is most probably the best analogue of Mars on Earth and studying it should allow a better understanding of the Red Planet. For that reason, it is necessary to build a Mars Analogue Research Station in this location, in order to test the instruments designed for future Martian missions, and, most importantly, test the operational environment of a station on Mars.

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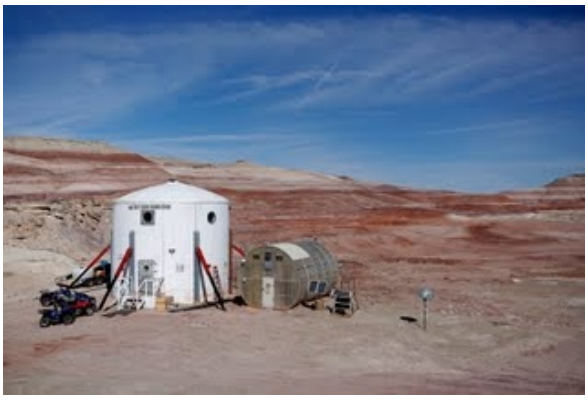
APPENDICES

[a] Flashline Mars Arctic Research Station (FMARS)
Source: [3]

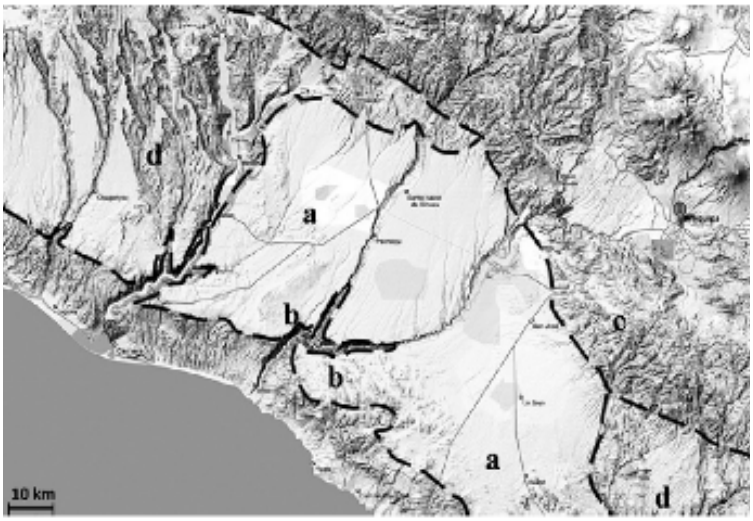
[b] Mars Desert Research Station (MDRS)
Source: [4]



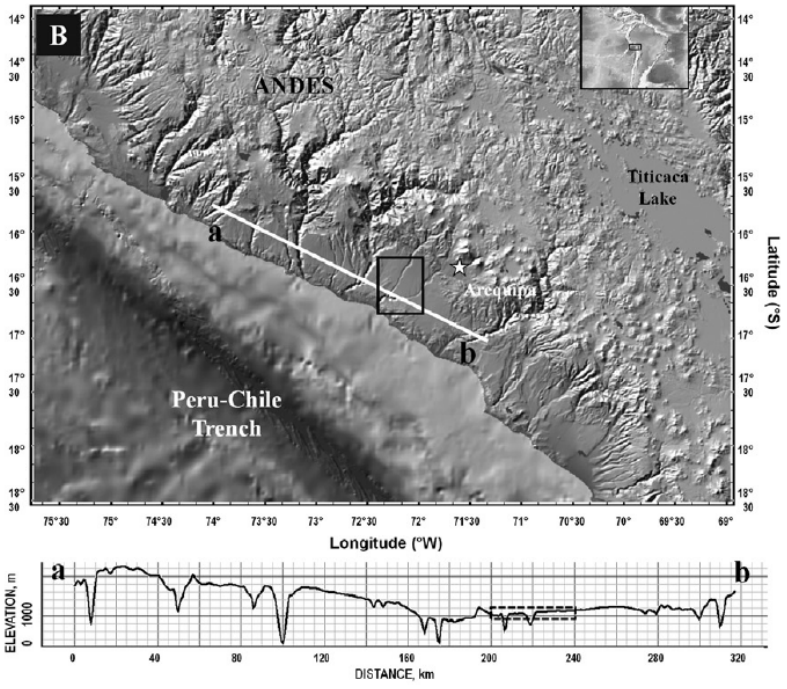
[c] Atacama Desert in South America
Source: http://www.geschichteinchronologie.ch/atmosphaerenfahrt-ESP/fotos-de-la-Luna/valle-de-la-Luna-en-Chile-ESP.html

[d] Location of La Joya city in the department of Arequipa, Peru.
Source: Google Earth

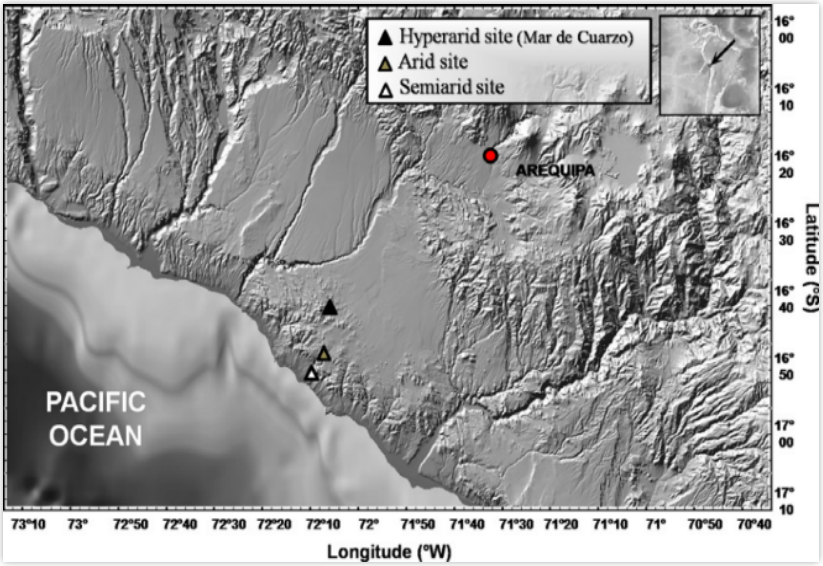
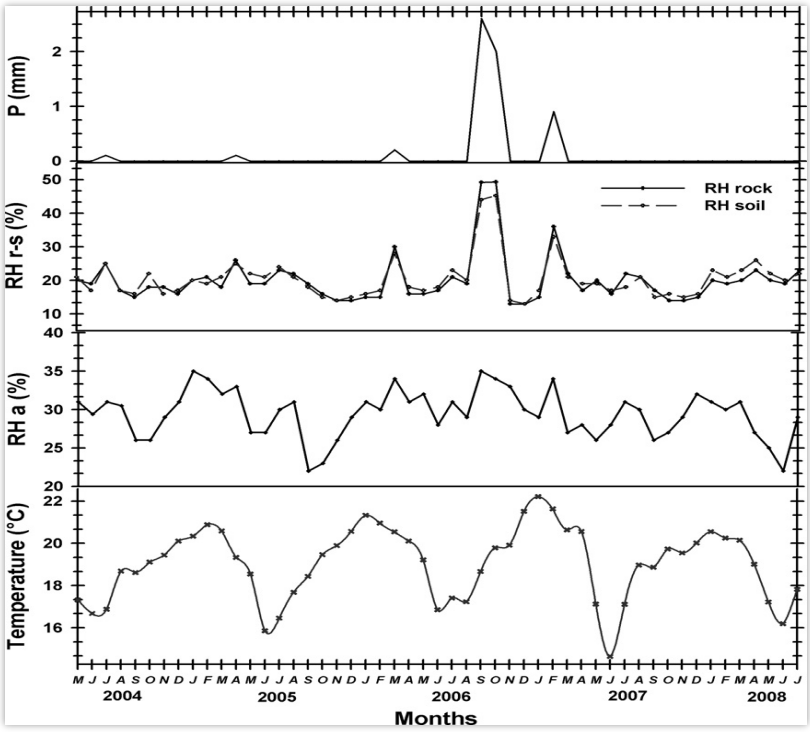
[e] Location of Pampas de la Joya Desert in southern Peru: (a) Pampas de la Joya, (b) Sihuas and Vitor river gorges, (c) Andean foothills, (d) Dissected desert plain.
Source: [1]



[f] Longitudinal topographic profile a-b across the desert plain of southern Peru between 17°S and 16°S, across Sea of Quartz (black rectangle).
Source: [1]



[g] Mar de Cuarzo (black triangle) and sampling areas.
Source: [1]



[h] Environmental data in Mar de Cuarzo. Four-year period of observation (May 2004 to August 2008). Top panel: precipitation (mm). Second panel: relative humidity (%) beneath the soil surface (0–5 cm) and rocks. Third panel: air relative humidity (%). Bottom panel: air temperature (°C).
Source: [1]