Martian/Lunar analogue research station in India: Ladakh as a potential site

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India has a rich geographical landscape suitable for creating extra-terrestrial analogue habitats, which are crucial for supporting prolonged space missions and addressing the challenges of sustaining human life outside of Earth. It is also imperative that these habitats are analogous, both in design and proposed locations, as accurately as possible for meaningful lessons and research. India has set ambitious targets for its space program, which necessitates the construction of terrestrial research stations that can simulate extra-terrestrial conditions. We believe this is an opportune time to establish an analogue research station in Ladakh, that will benefit a diverse group of researchers. It can potentially become a shot in the arm for the Indian human space program. Apart from research, the tourism boost that such a site can give will also benefit local communities.

Keywords: Analogue research, Ladakh, Lunar, Martian, terrestrial research station.

INDIA has set ambitious targets for space. The honourable Indian Prime Minister formally announced the Indian human space program on 15 August 2018. The Gaganyaan program seeks to place Indians in space on an indigenous vehicle (https://www.isro.gov.in/Gaganyaan.html). Towards this end, Indian Space Research Organisation (ISRO) formally inducted four astronaut designates into its ranks on 27 February 2024 when the Honourable Indian Prime Minister awarded astronaut wings to them. Besides the Gaganyaan program, India has signaled its intentions to have its space station, the Bharatiya Antariksha Station (BAS), and put an Indian on the Moon by 2040. India's plans for exploring the solar system extend beyond the Moon to Mars. The Mars Orbiter Mission-1 (MOM-1) of 2014 was ISRO's first mission to Mars, and follow-up missions have already been announced. While MOM-1 was an orbiter-only mission, future missions will likely involve rovers. These announcements signal the human space program's continuity; hence, India must work stridently towards developing infrastructure to support such a program. A key concept in furthering new technologies is the concept of extra-terrestrial habitat simulation. Such habitats are the critical first step in evaluating designs, testing materials, training personnel and performing scientific studies[1,2]. Analogue habitats also allow for the collection of significant data and the implementation of test cases with varying parameters. Simulation tests are essential for extra-terrestrial habitats, as these habitats are meant to be stand-alone units capable of handling all contingencies. A necessary condition for a successful extra-terrestrial space program is the setting up simulation facilities where scientists can collect data with Indian personnel and help provide inputs for future designs. Creating extra-terrestrial analogue habitats is crucial for supporting prolonged space missions and addressing the challenges of sustaining human life outside Earth. It is also imperative that these habitats are analogous, both in design and proposed locations, as accurately as possible for meaningful lessons.

India has several locations with diverse environments (deserts – cold and hot, caves, mountains, ocean/seas) that can serve as natural laboratories and training grounds to support upcoming Mars and Moon missions and for research. Isotopic measurements have revealed that the Earth and the Moon are made of the same minerals[3–5], with the difference being that Earth is a dynamic and 'alive' planet, whereas the Moon is still and 'dead'. Earth's surface is constantly changing due to the movement of crustal elements due to several endogenic and exogenic processes. On the other hand, the Moon's surface is mostly still, with no wind and traces of water in its polar regions. Finding an appropriate area for the Moon analogue is complex, whereas Mars, a terrestrial planet like the Earth, has several analogue sites. Table 1 lists a few of the numerous potential sites in India which can serve as experimental and functional analogue sites for Mars. Several researches have been conducted in recent years[6–11]. The Moon experiences extreme temperature variations due to its lack of atmosphere. Daytime temperatures can soar to about 127°C (260°F), while nighttime temperatures can plunge

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