SPACEWARD BOUND INDIA 2016: PRESENTING LADAKH AS AN ANALOG REGION FOR ASTROBIOLOGY RESEARCH AND HUMAN EXPLORATION OF MOON AND MARS.

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Introduction: The Spaceward Bound Program was developed at NASA Ames Research Center (ARC) with the first program held in 2006. Helping inspire the next generation of human explorers of Moon, Mars and beyond, the aim of the program is to enable participating students work with educators and researchers in scientifically exploring remote environmental analogs of Moon and Mars on Earth. Several expeditions have since been held in the US and globally in Chile (2006), Australia (2008,2011), Namibia (2010), UAE (2011) and New Zealand (2015). For the first time in India, the Ladakh region was chosen as the region of interest and a scouting expedition was held in August 2016 with an international team of reearchers, educators and students. The overall organization of the event was led by Mars Society Australia and Birbal Sahni Institute of Palaeosciences (BSIP), India with non financial guidance and overview support from NASA Spaceward Bound members at ARC.

Why Ladakh?: Ladakh is a unique very high altitude (~3500 m-5700 m above sea level) cold, desert region that offers road access to several kinds of microbial life supporting extreme environment analogs (glacial sediments, sand dune ponds, hot springs, saline lakes and permafrost regions) that can be all covered within a few days of travel. Researchers within the team conducted experiments, made terrain observation records, field tested a Mars mission flight instrument prototype and collected environmental data and samples for lab work. The team interacted with students from remote village schools in the region.

Expedition Objectives: The first objective was to identify regions in Ladakh with astrobiological relevance and scope feasibility for detailed future study in terms of science potential, access, resource availability, logistics and safety. The second strategic objective was to facilitate astrobiology teams based in India and outside to work together in the field and subsequently initiate collaborative work by formation of joint research groups. The third objective was to spread awareness on space exploration, importance of regions like Ladakh to groups that study other Worlds and search for life, in remote village schools of Ladakh and in New Delhi.

Region and Field Transects: Ladakh is a mountaineous district within the state of Jammu and Kashmir in Northern India. Its capital township Leh (34.1526° N, 77.5771° E) at 3500 m was the base for the team from which a transect each was covered to its north and south over 10 days. The first transect (North of Leh) was Leh- Khardung La- Nubra- Panamik- Hunder- Leh, a 320 km circuit. Khardung La, is a high mountain pass (5359 m above sea level) with access to residual glaciers and their deposits. Panamik hot springs and Hunder sand dune region were studied. The second transect (South of Leh) was Leh-Chumathang-TsoMoriri-Puga-TsoKar-Tanglang La-Leh, a 440 km circuit. This transect enabled exploratory visits to hot spring regions of Chumathang and Puga; saline lakes of Tso Moriri, Sumdo and Tso Kar; permafrost mounds of Tso Kar and glacial sediments at Tanglang La pass on the way back to Leh.

Figure 1: Tso Kar, Ladakh: A possible analog of saline lakes on Ancient Mars.

Science Team Description and Research Focus: The 31 member team consisted of researchers from India, Australia, US, and Sweden who had been working together remotely for a year before the expedition, studying the terrain maps and previous literature planning the experiments, site visits and required resources. The science covered sample collection for lab work, logging environment data (temperature, pH, humidity, UV), testing future mission instrument prototype and studying terrain features, all helping answer key questions of understanding evolution of life as we know it and the search for it on other worlds.

Microbial Diversity Research. The group studied microbial community structures and microbial biomass measurements of rock, soil, water samples from the several sites along the transects. Site and transect-wise temperature, humidity and altitude measurements were

logged to correlate with findings from the analysed samples.

Figure 2: Puga Hot Springs, Boron rich sinters could hold key to origins of life

Geochemistry Research. The group is analyzing water, mud samples collected from hot spring sites and permafrost mounds to isolate clay, conduct geochemical composition analysis. Some members are also studying carbon metabolism in the hot springs and boracic mud deposits.

Geomorphology Research. To understand Martian landscape evolution and palaeoclimate, group members involved are studying lake shoreline, sand dunes and high mountain glacial pass terrain evolution. The focus is to understand how aeolian and periglacial processes influence evolution of Mars analogous landscape.

Instrument Field Testing. Group members tested prototype of the HABIT [1] (Habitability: Brines, Irradiance and Temperature) instrument, which is part of the European Payload of the ExoMars 2020 mission to Mars (ESA/Roscosmos). Since, Ladakh and Mars both have a similar extreme environmental conditions (including cold temperature and high UV radiation) this work will provide a unique opportunity to validate HABIT as an instrument to assess the habitability of a harsh environment.

Education and Outreach Focus: The education component of the expedition covered field and 'end of day' discussions between participating scientists, educators and students as well as interactions with local remote school student groups on select days. A field location site visit involved terrain descriptions, landscape evolution descriptions and astrobiology relevance given by the geologists and veteran Spaceward Bound members. Students and educators helped the researchers collect samples and log environment data, thereby getting hands-on field training. On select days through out the expedition, end of day review of the day's findings and plans for the next day's site kick-started group discussions on relevant geology and geochemistry topics. Being an international interdisciplinary team working in a remote setting, the format could be developed to simulate and test several human-centric aspects of future international Moon and Mars expeditions. The team was able to experience and cope with 'in the field' logistical challenges faced while scheduling transport, resource arrangement, prioritizing sites within a time constrained visit while being under the stress of operating in a low oxygen environment. Educator members on the team led outreach projects at students from four remote schools in Ladakh region: SECMOL Ladakh, Panamik School, Puga Valley School, and Rengdum school. At each school, an interaction with groups of 30-40 students aged 3- 17 took place. Activities included showing short videos on Mars, making and launching paper rockets using compressed air,, looking at rocks through magnifying glasses and understanding how life grows under translucent rocks.

Follow up and Future Plans: The science group members are working towards analyzing results and publishing findings and conclusions from the expedition in due course in relevant journals and conference meetings. An expedition overview publication is also being compiled. Key findings from the science groups shall be discussed at a workshop in the near future in India. The conclusions from the findings from the visited sites shall pave the way towards the formation of a long term astrobiology exploration map for Ladakh. Several joint research collaborations have resulted post the expedition along the lines of the scientific focus described earlier. The collaboration of participating academic and research institutions with a private travel organization, involved government departments and private company sponsors was encouraging and a healthy sign for successful follow up small group and Spaceward Bound type expeditions to the region. Plans are underway for feasibility studies for a Mars Analog Research Station with a support base in New Delhi. Some of the team are involved in the formation of a proposed Centre for Astrobiology at the BSIP, which would be crucial to support future field and lab work, facilitate inter lab collaboration and workshops for students in the country. India, being a space faring nation with its recent success to put a spacecraft in Mars orbit, Mars Orbiter Mission or 'Mangalyaan' has much to offer to the world in helping answer key questions about Life in the Universe.

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