TOUGH LESSONS NEEDED FOR LONG-DURATION HABITATION WITH DUST.

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Introduction: The two most likely off Earth surfaces for future, long-duration human habitation are the Moon and Mars. The two environmental variables most concerning and complex to mitigate and manage are likely radiation and dust. The focus herein pertains to dust, and highlights the need to conduct long-term longitudinal studies, training, and concurrent systems design, development and testing, for operations in these dusty extraterrestrial environments.

A thorough characterization of long-duration off Earth human operations, hardware and habitat designs should occur at a terrestrial analogue site that offers a highly complex and potentially hazardous dusty environment. Multiple sites could support such research, but herein we highlight four extreme dusty locations chosen to initiate discussions, comparisons, and capability assessments: Bodélé Depression [1], Owens Valley [2], the Aral Sea [3] and Iceland [4,5]. The first three are of lacustrine origin, and currently represent the most dust laden locations on Earth. Iceland provides dust laden volcanic regions that are evolving under extreme erosional stress [6]. All four settings, more or less, support both lunar and Mars dust analogue needs.

The Need to Design and Test in Dusty Conditions: For equipment to operate safely over long durations, functional usage and life-cycle assessments within such environments need to be fully vetted and understood. This will likely require the installation of infrastructure (i.e. habitats with airlocks and mudrooms, akin to the Mars Society's analogue facilities [7]), which can easily support EVA operations, and hardware testing and development. The effects of dust on hardware, including hardware tolerance and mitigation efforts have lately been the topic of much work [8,9], and our knowledge would advance appreciably through long-duration field trials.

Analogue Field Operations and Training: The best analogue sites would simultaneously provide a good exploratory scientific field-research practice and training location for analogue participants, as well as in situ research locations for terrestrial investigations (e.g. environmental change, microbial transport, etc.). For example, the three lacustrine sites are important regarding terrestrial climate change, human land and water usage [10], and would provide ample research opportunities that would synergistically align with dusty testing and training scenarios.

Extreme Dusty Analog Sites: Fully immersing in worst-case conditions regarding dust hazards, directs us to examine specific dust laden sites on Earth. The four sites discussed each have a different provenance and evolutionary processes that make them well suited for dust production, geological field training and operational shakedown activities.

1) The Bodélé Depression in west central Chad (Fig. 1), is considered the dustiest location on Earth. The natural dusty conditions resulted from the desiccation of ancient Lake Megachad (NE of the remnants of modern-day Lake Chad). Dust originating in this region of the continent is believed to be transported across the Atlantic to the Americas.

2) The dustiest place in North America, and second dustiest in the world, is Owens Valley, California (Fig. 1). The valley is the single largest source of PM10 dust in the United States. The desiccation of this lake is a combined result from water management practices, usage and climate change.

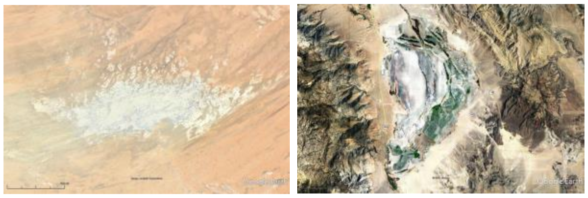

Fig.1 Bodélé Depression and Owens Valley

3) Estimated to be the third dustiest location on Earth, the Aral Sea (Fig. 2) borders Kazakhstan and Uzbekistan, and was once the fourth largest lake in the world. The desiccation of the Arel Sea began with river diversions in 1960 to support farmland irrigation and population growth.

4) Iceland (Fig. 2) has a number of expansive erosive locations that include sand, dust and ash. Particle size ranges and other basaltic physical and chemical properties may provide better analogues to extraterrestrial environments.

Fig. 2 Aral Sea and Iceland with major erosion areas (red).

Discussion: Dust is one of the greatest risks to all future long-duration sustainable surface development. Only well tested designs will survive operational and functional constraints, ensuring durability and mitigation needs for diminishing associated hazards. Given all variables combined including logistical extremes, geopolitical obstructions, and manmade pollution hazards, then Owens Valley is likely the best candidate for developing such a dusty analogue site. Iceland then, would likely be the second-best choice due to geology and historical planetary analogue collaborations.

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