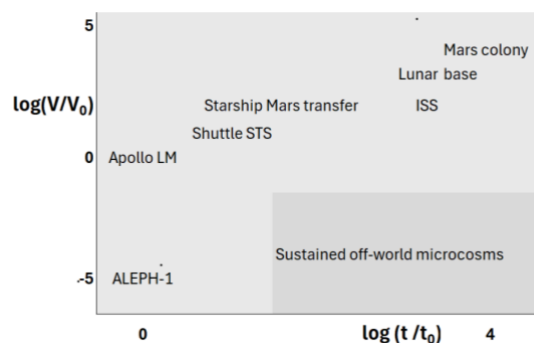


**LUNAR SURFACE MICROCOSM EXPERIMENT.** G. E. Dorrington<sup>1,2</sup>. <sup>1</sup>School of Engineering, RMIT University, <sup>2</sup>Lunaria One, PO Box 1106, Kangaroo Ground, VIC3097, Australia. [graham.dorrington@rmit.edu.au](mailto:graham.dorrington@rmit.edu.au)

**Introduction:** The realization of indefinitely sustainable human habitation on the Moon and Mars will be dependent on the continuous stable functioning of large-scale, closed ecological life support systems [e.g., 1]. The development risks of such systems could be mitigated by first performing short duration experiments on much smaller closed biological microcosms conducted in terrestrial laboratory settings [e.g., 2], in low Earth orbit [e.g., 3], and on the lunar surface [4, 5]. Here the term “closed” refers to any sealed enclosure that aims to minimize material transfer to and from the external environment [6]. To clarify “much smaller” Figure 1 offers a size comparison.

The Australian Lunar Experiment Promoting Horticulture/Habitation (ALEPH) project and its first intended lunar payload, ALEPH-1 includes an air-filled enclosure with an internal volume of just ~57 mL [7].



**Figure 1:** Comparison chart illustrating the volume ( $V$ ) and lunar surface mission duration ( $t$ ) of the ALEPH-1 microcosm with past and future-envisaged human habitats, referenced to the habitable volume of the Apollo Lunar Module,  $V_0 = 4.5 \text{ m}^3$  and its approximate mission duration (Apollo 16 and 17),  $t_0 = 72 \text{ h}$ .

ALEPH-1 has a planned delivery to the Reiner Gamma feature on the lunar surface ( $7.5^\circ\text{N}$ ,  $59^\circ\text{W}$ ) mounted on the third Intuitive Machines Nova-C lander in their IM-3 CLPS mission scheduled for the second half of 2026. ALEPH-1 will contain two 2-3 g rock samples with the crustose lichen, *Rhizocarpon geographicum* [8] growing on them. This holobiont is commonly found on mountain tops in, e.g., the USA and Australia, and has previously been shown to survive long duration flights on the ISS [9].

**Lunar science:** Compared with higher plants, lichens have simpler biophysics. Photosynthetic and respiratory gas exchange rates can be well-modeled using analytical expressions [10]. The null hypothesis is

that, provided the same internal microclimate (thermal, etc.) conditions are set-up (as that of a terrestrial control experiment), any measurable implied-metabolic parameters will be unaffected by reduced (lunar) gravity.

**Mission:** The primary mission goal for ALEPH-1 is to establish whether the necessary microclimate conditions allowing active lichen metabolism are attainable throughout lunar delivery and then for a nominal duration of 72 hours on the lunar surface. The intention is that this experiment will also provide a useful small stepping-stone towards other possible (longer duration) off-world microcosms (Figure 1).

**Thermal control:** ALEPH-1 employs thermostats to auto-regulate heater electrical power supplied by NOVA-C and passive surface coatings with low emissivity and solar absorptivity [7].

**Forward contamination:** COSPAR and NASA define near-equatorial lunar missions as being in Category IIa [11], with negligible risk of any forward contamination of the permanent shadowed regions near the lunar poles. A comprehensive lunar microbial survival model [12] predicts that the external surfaces of landed or crashed spacecraft are unlikely to harbor living bacteria and/or lichen spores after one lunation (~708 h) post-mission near the lunar equator.

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