HUMAN EFFICIENCY IMPROVEMENTS IN LUNAR AND MARTIAN FIELD EXPLORATION. H. H. Schmitt[1], [1]University of Wisconsin-Madison, P.O. Box 90730, Albuquerque NM 87199 (hhschmitt@earthlink.net)

Introduction: Apollo exploration of the Moon provided observations, data and samples that will continue to contribute new insights into the origin and evolution of that small planet. It truly is a gift that keeps on giving. [e.g., 1]

Pressure Suits: The required improvements in suits are: (1) a major reduction in forearm fatigue induced by the suit's pressure glove; (2) a major increase in the glove dexterity; (3) real-time passive and/or active dust rejection; (4) verbally controlled heads-up display (HUD); (5) verbally controlled communication modes and PLSS operations; (6) improved capability to bend or kneel to reach the ground; and (7) increased suit longevity, maintainability and *in situ* refurbishment.

Tools: Sampling tools, such as scoops, self-closing tongs, hammers, pre-numbered bags, vacuum-sealed containers, and core tubes, will remain the essential tools of lunar and Martian field exploration. Key new design elements will be connectors that can tolerate dust intrusion and still function indefinitely.

Reliable and high resolution digital color imaging systems also will be required, preferably with automatic recording of system orientation and range to image subject.

Portable analytical tools may be valuable additions to EVA quality; however, they also may lead to a loss of efficiency in overall exploration. Trade studies should be conducted that evaluate their use in the field versus their use between EVAs in habitats.

Experiments: Although human dexterity can be of great value in facilitating the deployment of some specialized or unique experimental hardware, such as seismic geophones and energy sources, valuable exploration time should not be used for this purpose if avoidable. If feasible, robotic or tele-operated deployments are to be preferred. Equipment designs, however, should anticipate human intervention in the event of initial failure of such deployments.

Experiments or sampling that require drilling into the lunar or Martian regoliths should utilize robotic or tele-operated systems rather than human operators. Drill design, however, particularly for the closely packed lunar regolith, needs to mitigate the problems of drill stem extraction encountered by Apollo crews. [2]

Dust Mitigation: In addition to layered defenses against dust penetration into habitats, protection against the wear and jamming effects of dust will be essential for any exploration activities on the Moon and Mars. These measures should include recognition of the substantial physical and compositional differences between lunar and Martian dust.

Crew Experience: The Apollo lunar exploration experience shows that value of each exploration minute will be enhanced immeasurably by the inclusion of professional field geologists on lunar and Martian crews. [3] The same can be said for both field geologists and biologists on Martian crews.

References: [1] LSC and LPSC 1-49 (1970-2018); Schmitt, H. H., et al. (2017) *Icarus*, 298, 2-33; Schmitt, H. H., et al (2018) *LPSC 49,* Abst 2961. [2] Schmitt, H. H. (2017) *LEAG Annual Meeting,* Abstract. [3] Schmitt, H. H., et al. (2017) *Icarus*, 298, 2-33; Schmitt, H. H., et al (2018) *LPSC 49,* Abst 2961; Schmitt, H. H., et al (2011) *GSA Special Paper*, 483, 1-16.