

**ASTRONAUT GEOLOGICAL TRAINING FOR LUNAR EXPLORATION.** M. A. Helper<sup>1</sup>, H. H. Schmitt<sup>2</sup>, W. R. Muehlberger<sup>1</sup> and A. W. Snoke<sup>3</sup>, <sup>1</sup>Department of Geological Sciences, Jackson School of Geosciences, University of Texas, Austin, TX 78712; [helper@mail.utexas.edu](mailto:helper@mail.utexas.edu), [wmuehl@mail.utexas.edu](mailto:wmuehl@mail.utexas.edu), <sup>2</sup>University of Wisconsin-Madison, P.O. Box 90730, Albuquerque, NM 67199, [schmitt@engr.wisc.edu](mailto:schmitt@engr.wisc.edu), <sup>3</sup>Department of Geology and Geophysics, Dept. 3006, University of Wyoming, 1000 East University Avenue, Laramie, WY 82071, [snoke@uwyo.edu](mailto:snoke@uwyo.edu)

Lunar outpost and sortie missions will require astronauts with specialized training in geosciences. Whether it is *in-situ* resource assessment, geological site characterization, sample collection/documentation, or any of a host of other engineering and science objectives, maximum benefits will only accrue from crews that are well-trained in the techniques of geological, geophysical and geochemical field exploration, and that have a strong background in lunar science. An experienced, well-trained geological observer is a decision maker who can intelligently explore, recognize, and sample the essential and unique elements of a field site thoroughly and efficiently, is a master of the tools of the trade, and has a vocabulary adequate for recording observations. Although it is anticipated that many lunar crews will contain field-trained geoscientists, astronaut-pilots and/or other mission specialists that are crew members will need to acquire adequate exploration skills. Such training should draw upon Apollo training experiences, and should contain both field- and classroom-based components. The incorporation of post-Apollo technological advances (e.g. geographic information and positioning/navigation systems, digital photography and data acquisition, field spectroscopic equipment, robotic assistants, etc.) may require significant development, testing and crew training before they can be seamlessly integrated into lunar field work.

Field training should progress from acquisition of the basic skills of observation, sampling, equipment usage and sample site documentation to mission-oriented simulations at analog sites. Mission simulations should include exploration traverses and tasks that closely mimic the crew's lunar mission in all respects, including uplink to support staff at the Mission Control Center. Following the Apollo model, trainers should include geological mentors of exceptional experience in teaching field geology, training sessions should include multi-day immersive experiences on a monthly basis, and the training program should have sufficient institutional support to cover the logistical and organizational activities associated with field-based instruction.

Knowledge of lunar geology provides the lens through which field observations and exploration are focused. Classroom training should impart 1) a basic understanding of general geologic concepts relevant to lunar and planetary exploration; 2) what is and is not known about the Moon; 3) principles of field geologi-

cal observation and sampling. On the basis of the Apollo experience, background subject areas of greatest relevance are impact crater geology, regolith geology, planetary geophysics, lunar igneous geology and element/isotope geochemistry. Such training is most effective and meaningful when classroom and field training are integrated to the greatest extent possible. Terrestrial field sites can provide significant hands-on experience in impact crater and igneous geology, as can lunar samples for regolith geology and the petrography of lunar materials. Geophysical training should include field instruction in gravity, magnetic and seismic data acquisition.