ASTRONAUT LUNAR FIELD EXPLORATION TRAINING. J.W. Rice, Jr.[1], A.J. Feustel[2], and J.F. Reilly II[2] [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, jrice@asu.edu, [2]Astronaut Office, NASA Johnson Space Center, Houston, TX 77058.

Introduction: Astronauts have not explored the lunar surface since December 1972. NASA's new plans for the manned return to the Moon revolve around the construction and establishment of a lunar polar outpost starting around the year 2020. Therefore, in order to achieve NASA's new exploration objectives it seems prudent to dust off certain aspects of the Apollo playbook. The six Apollo lunar landing expeditions provide us with the only experience for manned surface exploration. It seems reasonable to assume that some of the guiding principles and lessons learned from Apollo will be useful in the scientific training of the crews for these new lunar expeditions.

The Apollo Approach: The Apollo astronauts received extensive geologic field training to insure maximum scientific gain and reduce risk to the EVA team. These field exercises proved to be invaluable and contributed greatly to the achievement of all lunar surface science objectives (including intelligent sample acquisition and documentation). Moreover, these field based exercises were also useful in sharpening the skills and interaction of astronauts and the ground science teams. The Apollo astronauts felt that they had been too rigidly scheduled during their surface EVA's and recommended that this should change. They also stated that the crew should be "essentially autonomous" and have a more dynamic role in planning the mission than they had during Project Apollo [1].

New Approaches: Technological developments since Apollo should be implemented into this next phase of manned lunar surface exploration. Some examples would include handheld spectrometers, hi resolution digital imaging systems, electronic field notebooks loaded with remote sensing datasets and maps, bar coded sample bags etc. Machine systems will also relieve astronauts of routine and hazardous tasks during EVA. Robotic and teleoperation systems should be designed to achieve an optimum mix of human and machine resources as safety, productivity, and cost effectiveness warrant [2].

Crew Skills: Experience shows it is best to select a crew weighted toward the primary scientific skills for the extensive surface mission, and cross-train them to accomplish the spacecraft systems, operations, and maintenance functions [3]. Apollo, Space Shuttle and ISS experience indicates that scientists can successfully acquire the essential mission operations skills in just a few years of spaceflight training, while the reverse process of training pilots and technicians for a primary science role will not work on a similar time scale. Geologist and Apollo 17 astronaut Jack Schmitt's estimate is that during Apollo, the scientists had acquired 75% of the operations skills of the pilots in the program, while the latter had attained 25% of the field geology skills typical of active field geologists. Successful cross-training can be accomplished over a period of about 10 years [3].

Field Training: Field geology is an iterative process and it can only be learned by actually performing field investigations. Most geologic field studies are founded on direct observation and measurement of features such as landforms, sediment grain size and morphology, rock textures, and geographic relations between rock bodies. These are objective data. But another kind of information is interpretive, for example associations of rocks and sedimentary structures imply specific genetic conditions or environments. This approach has great power because genetic insight can clarify a host of interrelated data [4]. However, interpretation is highly dependent on the geologist's experience. Fieldwork requires extensive traverse planning and assessment. However, it is not uncommon to find in the field that pre-planned traverses must be altered due to unforeseen discoveries or trafficability issues. This necessitates making immediate field decisions which can impact the overall field strategy planned for the duration of the field season (mission). This requires creativity and flexibility combined with field gained experience. Field geology is a slow process. Field geology in a space suit is an even slower process because most of the tasks will take longer and or be much more difficult to accomplish (taking notes, for example). Therefore, it is imperative that training begins sooner rather than later. Analog sites will be important for developing the crew's observational skills, operational techniques, and testing EVA systems and equipment. Most of the Apollo analog field sites should be revisited because these sites are well documented and logistically accessible i.e., Meteor Crater, Hawaii, NE Arizona. However, some new sites may also become incorporated.

Risk Reduction and Crew Productivity: The rationale for geological field training exercises is to reduce operational risk to the crew as well as increase crew productivity. The establishment of an ongoing program of scientific field exercises in support of lunar base development and ultimately geared toward lunar surface exploration will allow astronauts to gain valuable experience in managing a field research program, practice on site decision making, cope with changing research strategies, and to develop the cross training necessary for a successful expedition [5]. Astronauts participating in lunar analog field work should be equipped with the same tools and equipment that they will use on the Moon in order to practice techniques and to allow the crew members to become familiar with the capabilities and limits of their equipment. These analog field expeditions should also blend real scientific field work by the astronauts with a ground support team. These activities will foster the required interaction between the field team and ground support teams. Finally, these analog field expeditions should be geared toward accomplishing real scientific work not merely observation.

Conclusions: We advocate that an astronaut geology / geotechnical training program (to include field methods in geology, geophysics, and geochemistry) should begin sooner rather than later because the art and skill of field geology can only be learned by active participation in the field. Field geology is a cumulative science, meaning the more experience one gets the better one gets. Also the links should be forged between the science, operations, and astronaut communities now because it will take time to achieve the collective experience level necessary for the proper interaction of these communities. Training the current cadre of astronauts is also important because some will have senior management positions by the time we are ready for this new phase of lunar base development and exploration.

References:

[1] Conners, M. et al. (1994) *NASA TM 108846*.[2] NASA JSC-STD-3000 (1995), *Volume I - Man-Systems Integration Standards.* [3] Jones, T., et al. (1999) *LPI Contrib. No. 968*,25-30.[4] Compton, R.R. (1985) *Geology in the Field*, 398p.[5] Muehlberger, W.R., et al., (1999) *LPI Contrib. No. 968,* 5-13.